DOCUMENT RESUME

ED 384 486 SE 054 181

AUTHOR	Daniels, Jane Zimmer, Ed.; Kahle, Jane Butler, Ed.
TITLE	Girls and Science and Technology. Proceedings and Contributions of the GASAT Conference (4th, Ann Arbor, Michigan, July 24-29, 1987).
SPONS AGENCY	National Science Foundation, Washington, D.C.
PUB DATE	Jul 87
NOTE	1,292p.; Some pages contain very small, light type.
PUB TYPE	Collected Works - Conference Proceedings (021)
EDRS PRICE	MF10/PC52 Plus Postage.
DESCRIPTORS	Career Development; Classroom Research; College Science; Educational Research; Elementary Secondary Education; *Equal Education; Foreign Countries; Higher Education; *Intervention; Professional Education; *Program Evaluation; Science Education; Science Teachers; Teacher Behavior; Teacher Education; *Technology Education; *Womens Education
IDENTIFIERS	Attitudes Toward Science

ABSTRACT

In 1979, North European researchers met informally to discuss issues regarding women in science. In addition to discovering that the issues raised crossed national boundaries and cultural differences, they found that numerous efforts were underway to address their concerns. What started as an informal meeting has evolved today into an international effort that enfolds a conference (GASAT-Girls and Science and Technology). The fourth GASAT conference hosted by the University of Michigan focused on the attraction, retention, and achievement of girls and women in scientific and technological courses and careers. Papers presented in "Contributions" volumes I through III are as follows: (1) "The Monopoly of Classroom Discussion by Boys as a Misleading Measure of Superiority in Science"; (2) "Analogies Promote Learning in Science"; (3) "Teachers' Differential Treatment of Girls in Technological Education--A Celebration of Diversity?; (4) "Are the Girls the Problem? Gender and Computer-Science in the Danish Secondary School System; (5) "Does That Train-Set Matter? Scientific Hobbies and Science Achievement and Choice; (6) "Through the Looking Glass of a Swedish Science Teacher"; (7) "Why are Many Girls Inhibited from Learning Scientific Concepts in Physics? (8) "Girls' Concept of and Attitude toward Technology. The International Patt-Research"; (9) "Females and Physical Science: Is Tinkering an Issue?; (10) "Women's Access to Scientific and Technological Activities in Mali"; (11) "What do Children Think? A View of Science and Scientists"; (12) "Rational Girls and Girls' Rationalities"; (13) "Research Work of Men and Women in Science and Technology"; (14) "Israeli High School Boys and Girls Achievement and Attitudes toward Science"; (15) "The Effect of Same-Sex Role Models on Perceptions of Performance in Science Courses"; (16) "Some Proposals for Integration of Affective and Cognitive Aspects in Physics Education"; (17) "More Girls to Technical Jobs-An Action Plan"; (18) "Psychological Type and Science Career"; (19) "Labour Market Division in Sweden and Its Effect on Attitudes and Education"; (20) "Is There a Place for Women in Biosciences?"; (21) "An Evaluation of Efforts Made in Nigeria To

Increase the Participation of Girls and Women in Science and Technology"; (22) "Desexing Computing"; (23) "A Bibliometric Study of the Wisest Women in Pure and Applied Science Bibliography"; (24) "Guidelines for Sex Equity in Textbooks"; (25) Evaluation of a Project Designed To Encourage Girls To Take Up Technical Options in Rural Schools"; (26) "Chinese Women Rise with Force and Spirit in Science and Education"; (27) "The Half Sky--Woman Scientists in our Institute"; "'Radical Feminist Analysis' and GASAT: Some Possible Conflicts?"; and (28) eight articles on intervention efforts. Volume IV, a record of the "Proceedings" that was prepared and distributed after the conference, contains welcoming remarks, theme presentations, and reports of workshops and special interest sessions. Topics highlighted in volume IV are: (1) intervention, i.e. the linking of research and practice, the importance of working at many different levels in many different ways, making use of networks/friendship groups, and the question of co-ed or gender segregated education; (2) GASAT volunteer workshops and special sessions; (3) Gender and Science, including the Squibb International Seminar; and (4) the recruitment of women into science and engineering, including one article by Ina Wagner. (ZWH)

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VOLUME ONE

CONTRIBUTIONS TO THE FOURTH GASAT CONFERENCE

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July24-29,1987
The University of Michigan, Ann Arbor, Michigan U.S.A.

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Edited by
Jane Z. Daniels
Jane B. Kahle

CONTRIBUTIONS TO THE FOURTH GASAT CONFERENCE

University of Michigan
Ann Arbor, Michigan, U.S.A
July 24-29, 1987

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Publication sponsored by The National Science Foundation

GASAT 4 SCHEDULE

DATE / TIME	Friday July 24	Saturday July 25	Sunday July 26	Monday July 27	Tuesday July 28	Wednesday July 29
	THEMES	INTERVENTION	RESEARCH	RESEARCH	EVALUATION	ASSESSMENT
7:00 - 8:00		Breakfast	Breakfast	Breakfast	Breakfast	Breakfast
8:00 - 10:15		Theme Presentation	Theme Presentation	Theme Presentation	Theme Presentation	Summaries
10:15 - 10:45		Coffee	Coffee	Coffee	Coffee	Checkout
10:45 - 12:00		Discussion Groups	Discussion Groups	Discussion Groups	Discussion Groups	Reception (11:00-12:00)
12:00 - 13:00	Arrivals & Registration	Lunch	Lunch	Trip to Greenfield Village 12:00 -	Lunch	Lucheon Announcements
13:00 - 14:30		Speaker or Discussion	Speaker or Discussion		Speaker or Discussion	Squibb Panel
14:30 - 15:00		Tea	Tea		Tea	Adjournment
15:00 - 16:00		Topic Summaries	Topic Summaries		Topic Summaries	
16:00 - 17:30		Free Time or Special Interest	Free Time or Special Interest		Free Time or Special Interest	
17:30 - 19:00	Supper	Supper	Picnic		Banquet	
19:00 - 22:00	Art Fair (Largest U.S. outdoor art fair)	Entertainment	Reception		International Talent Show	(National GASAT begins)

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A WELCOME

Two years ago in London, immediately following GASAT 3, a group of participants began planning GASAT 4. We met informally in the foyers of theaters and in the wine bars of London, and we concurred that GASAT 4 must have broader participation and must demonstrate the commitment of all to opportunity and to peace. Later, the Americans among that group formed the Planning Committee, which has been responsible for all aspects of GASAT 4.

The Planning Committee has been assisted in attracting international participants by the members of the International Committee and by Professor Jan Raat and Dr. Ilja Mottier. In addition, the formation of an Advisory Committee helped to ensure a broad spectrum of American support. Each of these committees has worked hard to achieve the theme of our conference *GASAT 4--A Celebration of Diversity.*

From July 24th to 29th in Ann Arbor, Michigan, men and women from diverse cultures will focus on the opportunities and challenges for girls and women to achieve their diverse potentials in science, technology and engineering. Together we shall celebrate the diversity;

- the diversity of people and cultures,
- the diversity of opportunities and challenges, and
- the diversity of science, technology and engineering

On behalf of each member of the Planning Committee, I welcome each contributor to the unique network of GASAT, a group of diverse people working toward a common goal.

Jane Butler Kahle

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University of Michigan

PREFACE

This book is Volume 1 of a three volume set of papers edited for the fourth international conference of Girls and Science and Technology-GASAT 4. The conference follows those held in Eindhoven, The Nethelerlands - 1981; Oslo, Norway - 1983; and London, England - 1985.

GASAT 4 will be held in Ann Arbor, Michigan at the University of Michigan on July 24-29, 1987. The submitted papers and conference proceedings will increase international knowledge and understanding of the value and diversity of the contributions of girls and women to science and technology and of the issues that affect such contributions. Special outcomes will include a better understanding of:

- -barriers to women's education and participation in scientific and technological fields.
- -strategies and interventions that can and do help to change or surmount those barriers.
- -resources of people and materials, available around the world to assist and reinforce the work of Conference participants and their colleagues at home.

Participants in the GASAT 4 Conference represent 30 different countries. The papers written by these participants have been organized under the following headings:

-RESEARCH: Experimental
Qualitative
Empirical, Quantitative

-EVALUATION: Evaluation of Existing Situation and Recommendations
Evaluation of Specific Programs
Description/Case Studies
Theories and History

-INTERVENTION PROGRAMS

The papers within each area are organized alphabetically by the first author's name. The three volumes of papers will be mailed to all particpants prior to the conference. Disscussion sessions will be held at the conference, focusing on each of the areas listed above. Following the conference, a book of conference proceedings and a congress book will be sent to everyone in attendance.

We hope that the research and experiences summarized in these three volumes expand your horizons and stimulate your thinking.

Jane Zimmer Daniels

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The Monopoly of Classroom Discussion by Boys as a Misleading Measure of Superiority in Science

Esbar, N.   Levin, T.

Tel-Aviv University, ISRAEL

Summary

The study aims to compare girls' performance with their peer boys in a special program called "research class".

Eighteen secondary school eleventh grade students volunteered for a special "research class" in Biology from a wider group chosen for their excellent performance in science. This class special studies included three supplemental hours of biology a week at school, and one full day a week at a research institute. At the institute they were required to conduct individual research projects under both the guidance of a scientist and the supervision of their biology teacher, the program initiator who accompanied them during each of their days at the institute throughout the school year.

The data was collected through frequent non-participant observations, primarily at their school and less frequently at the research institute. These observations was then followed by interviews of all the adults and students involved in the project, and by questionnaires completed by the students.

The main findings of the study indicated that the boys were significantly more active in classroom discussions than the girls. This observation was reconfirmed by an analysis of classroom-discussion interventions. Apparently, the girls are aware of their lower participation, which they relate to their "need for full comprehension before being able to contribute and participate in classroom discussions" in sharp contrast to the boys' easy-going participation. However in both the teacher's evaluation and the students' self-evaluation of their achievements, the girls' ratings were at least as high as the boys, with an average of 9 on a scale of 10. The boys' monopolizing at the classroom discussion is even more misleading when the scientists' evaluations are considered. They were notably impressed with the girls' ability, intellectual curiosity and sense of responsibility.

This is an on-going study where in the students are now completing the final work on their individul or team projects.

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The Study

This study was part of a more comprehensive one which followed a recent innovation in science education in Israel - an attempt to incorporate high school students into the research community. From the eleventh-grade s highest achievers in science eighteen volunteered for this special Biology program called "r esearch class". This program required a much greater input of time both from the students and from the teacher. The students who assumed this responsibility studied and worked much more than the regular student s national matriculation requirement.

From the beginning of our observations in the classroom we noticed that the boys (11) were more active in discussions than the girls (7). The immediate impression the observer had was that the boys were much more "into" the studied topic, whatever it was, and commented or responded enthusiastically, even if they were not always right.

The "division of power" into active boys and passive girls triggered our curiosity for further study.

Revelle et al (1984) conducted a study in a computer youth camp and noticed that the number of girls comprised only 15% of the participants. The researchers who organized a workshop within the camp indicated that only boys volunteered. Interviewing the girls, the researchers discovered that it was not a lack of interest which inhibited their participation. It was rather their wish to avoid having to compete with boys for a place in the workshop. "Power play for access" is a fact mentioned in other studies about sex differences. Sanders (1984) lists further sex difference speculations related to science and work with computers. She reports that girls yield to power, are concerned with their furture, and make efforts to understand instructions. Thus requiring sufficient time to assimilate those instructions. Boys tend to play with power, expect to satisfy present needs, and carry on manipulation as they learn-hoping to understand the instructions. Thus, boys find surplus time boring.

Stevens (1983) found that teachers from both sexes devote more time, attention, and consideration to boys in a mixed sex classroom. Boys demand attention by dominating classroom discussion and by sitting in the front. However, Gallagher (1967), who studied different methods of the presentation of concepts, noticed that in spite of the girls' low level of participation in classroom discussions (in comparison to boys) their achievements were equal. Stevens (1983) claims that even college teachers in Humanistic subjects where girls tend to excel, expect more of their male students. As a rule, everyone's expectations from girls are lower: the girls themselves, their parents, their teachers and so on. Being aware of these findings in the literature, we wanted to know: 1) If sex differences were also identifiable in high acheivers; 2) If different sex modes of classroom participation reflect differences in the quality of work and; 3) If there sex differences, so far observed in the U.S. and the U.K., also exist in Israel (where women are expected to share in the obligations of military service, domestic income, etc.)

Methodology - In collecting our data during the year of study we used a naturalistic approach where in a non-participant observations we compiled complete protocols of the classroom lessons. Thirteen protocols were content analyzed to obtain data about classroom interventions. An intervention was defined as any sentence or word uttered by a student. An open expectation questionnaire was also given to the students. Further, a self- evaluation questionnaire, with five categories, was given to the students by the teacher and was analyzed, for example: 1) "How serious was my attitude towards the classroom lessons? (measuring attitude), 2) "To what extent did I fully understand the studied topics (measuring understanding). A focused interview was carried out with the students, their counselling scientists, and the teacher, for the purpose of cross validating the information gathered through the observations and questionnaires.

Information about expectations from the program was gathered in preliminary interviews with the school administration and the project teacher. The students were asked to express their expectations in writing.

Findings

Kinds of Expectations and the Nature of Interventions

In their articulation of the reasons why they volunteered for this program, the girls emphasized possible "gains" for the future, while the boys pointed out the role this program played in satisfying a current need. This type of reasoning is similar to that which was found in Revell's et al (1984), study.

Table 1 shows the distribution of interventions as excerpted from the 13 observations.

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Table 1. Frequency : Type of interventions during classroom discussions (in actual numbers and percentage)

	Questions			Answers			Requests for repeat explain	remarks	humor	problem solving (Black Board)	Total inter-ventions
	A	B	C	D	E	F					
Boys	5	55	14 -	9	16	93	1	51	13	2	259
(N=11)	28.5%			46.5%			0.4%	19.1%	5%	0.8%	100%
Girls	2	26	3	1	1	11	15	12		2	73
(N=7)	42.4%			17.8%			20.5%	16.4%		2.7%	100%

Key to type of interventions.

A - Technical; B. Further clarifications & comprehension; C. Advancing the discussion; D. Wrong; E. Partially correct; F. Correct

Table I shows that the boys instigated about 75% of the interventions during classroom discussions while the girls were significantly quieter. As to the type of interventions made, the boys were active mainly in giving answers (46%), even if they were partially or totally wrong. The girls were active in raising questions (42.4%) for further clarification, daring to answer only when they were certain to be correct. Tests for significance are not noted due to the small N. The girls' lack of confidence and need for complete understanding is expressed by their high rate of requests for repeated explanations. The girls tended to say "I don't understand anything" or "can you explain again" in quiet, passive tones, while the boys made comments, even without full comprehension, or pointed specifically to where their problem lay. Yet, in spite of the the overall distribution of classroom interventions which were so dominated by the boys, there were still a few boys as quiet as the majority of girls, as Gallagher also found in 1967.

Teacher's and student's self evaluation

To uncover further differences between the sexes we have analyzed the self-evaluation questionnaire based on five categories: attitudes, comprehension, completion of tasks, evaluation of tasks, classroom activity.

Table 2: Average of Students Self Evaluation and their Teacher's Grades in the First School Term

Category	Attitude	Comprehension	Task completion	Task evaluation	Class activity	Students average own grade	Teachers grade
Boys grade (N=11)	8.7	9.1	8.1	8.4	8.4	8.5	9.0
Girls grade (N=7)	8.5	8.2	8.7	8.7	7.8	8.4	9.1

The grades are on a scale of 10.

Table 2 shows that in spite of the girls' lower level of classroom activity, they are clearly not behind the boys in the overall teacher's evaluation. The girls' evaluation was more homogeneous than that of the boys based on their S.D. (Boys 0.9; girls 0.4). In both sexes, the self evaluation was lower than the teacher's evaluation. Both sexes high attitude to the program is not surprising since they were pre-selected and had then volunteered to be there. However, the boys assess higher their own understanding of the studied topics. The girls did complain to each other that when they failed to understand a topic they did not insist upon their right to fully comprehend it before moving on. Actually, from Table one we can see that more than 50% of the girls' interventions relate to repeated and further clarifications. However, in evaluating both task completion and task quality, the girls gave themselves higher ratings. One girl wrote, "The written tasks were essential to understand the material more profoundly". On the other hand, one boy wrote: "I did the tasks but didn't enjoy it, I actually didn't have enough energy for them". In classroom activity (including listening, concentrating, comprehension, relevant questioning, proper answering, etc.), the lower ratings of the girls plainly reflects their lower classroom participation as this was part of the criteria for grading.

However, all the girls found it necessary to justify their lower level of participation. "During the lessons I was passive though fully listening and thinking, and not actively questioning or responding. This is true of me in all subjects". In one of the observations, this girl, who was evaluated highly by the teacher, presented her topic in a low voice, blushing, and for not more than five minutes while she could have easily taken more time, considering all that she had to say. After her, a boy

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gave his presentation for 25 minutes, and after him another boy took more than 20 minutes to present his topic, each using much more time than was needed. As the observer mentioned, "they liked the podium". Another girl commented about her participation: "I have listened; I had little previous knowledge. My participation was low, but this problem is not specific to this program only". Another girl wrote: "At the beginning, I had difficulties to adjust to this type of instruction and I could not express myself sufficiently."

Evaluation by the Scientists. For various reasons, only thirteen students completed the program from the initial eighteen. The remaining girls (5) received very high evaluations, while 2 of the remaining boys (11) did not. The scientist who did not have a successful relationship with his student team said about one of them: "I am surprised that this boy was admitted to this class. Although he is a quick thinker, he is immature and lazy. He needs to mature first". Other than that the evaluation was exceptionally high and the scientists used superlatives for either sex. "I am very impressed by the quick way in which the two girls were integrated in our project, with their ability, intellectual curiosity, reliability, and sense of commitment." Another scientist, who was at first hesitant to undertake the project, when interviewed said: "I am very happy that I decided positively. I am astounded at the analysis of data that was presented. I believe that this is a unique opportunity to guide such students."

As the program is still going on the final grading is yet to come. It will be based on the following factors: the students' team or individual project proposal; the process of its execution; their analytical deliberations; and the writing up of their work—the current stage of the program.

Discussion and Implications

It is interesting to note that all of our findings had already been reported in the literature, some as early as in the sixties. However, in studying this issue in the late eighties, we were struck by an anomaly. After a decade of rapid growth in the number of explicit feminine projects set to overcome girls' under-representation in science and technology, and a burgeoning of literature describing both practical operations and the construction of theories, one would have expected a change. Not only that, but this data was collected from a chosen group of both sexes who, excelled in their studies, were selected to participate in this "research class), and who come from a society that expects both sexes to share in responsibility. Nevertheless, the results tallied well with what is already known about sex characteristics). More surprising are the sex differences even considering the role model effect in a program that was initiated and tought by a highly motivated female (Smith&Erb 1986). From the observations (Table One) we notice that the teacher's "pets" were boys, as they were with the other reported teachers. When questioned about this unbalanced sex participation, the teacher said that "it doesn't make a difference". The teacher was not aware of the fact that girls were less active especially when the activity was based upon comprehension. Nor was she even sensitive enough to their need for further explanations. She carried on the classrom discussion with the boys, (75% of the interventions) and made no direct attempt to raise the level of the girls participation, despite the fact that classroom discussion was her salient teaching strategy. Still, the teacher's evaluation of the girls was objective and very positive: The boys' over-all evaluations as given by the boys themselves, the teacher, and the supervising scientists, were not higher than what was givean to their peer girls. Can we assume, therefore, that these individuals know that verbal participation was not always a sign for knowledge, thus confirming Gallagher's (1967) early finding that active classroom participation is not necessarily an indicator for higher acheivements?

It is obvious that the girls did not dare to respond unless they were certain about their answers. This confirms Revelle's, et al. (1984) observation that girls did not begin to operate the computers before reading and understanding the instructions, while the boys tended to learn as they went on operating. The girls concentrated in the classroom and if they did not understand the topic in question, they made a concerted effort later at home. Since the girls did sooner or later understand the topic, they therefore rated themselves high for comprehension albeit this comprehension often occured after the lesson.

Because most of the girls indicated that their low level of classroom participation was not only particular to science classes but was characteristic of them in general, it is recommended that girls' assertiveness must be progressively developed. It is assumed that girls' sex image at this critical age of adolescence also has its impact on their desire to keep a low profile and a less active role where ever overt competition is perceived or feared (as female competitiveness might be

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perceived as unfeminine and thus unattractive). It seems that the expected social norms are so strong that even in a high status project with high achievements these social norms set the tone. It therefore looks as if a concentrated effort to change these norms should turn into a national target if a country wishes and see a change.

Deliberate involvement and classroom roles leading to higher participation, are some of the tactics that should be used already in teacher education. Teachers should be alerted to these kinds of sex differences and sex biases and lead to more balanced interactions. We don't need to wait until girls face the job market where they will choose lower status jobs because of their lack of assertiveness, and not because of ability. We should start working on assertiveness early in a young woman's upbringing, and alert all the adults involved in this process to her specific needs and abilities. If we are to hope for a real change in the present occupational and economic discrepancy between the sexes, we must start the moment the baby is born or even better with the education of expecting parents.

It is obvious that there is no easy solution. From the GIST experience (Kelly, 1985) we know that even a structured multi-dimensional action aimed to overcome girls' under representation in optional science classes, and implemented in cooperation with teachers, claimed only very partial success. Yet, such action and others ought to increase in number and be evaluated if a change is expected to actually happen and to last.

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ANALOGIES PROMOTE LEARNING IN SCIENCE

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Background

One of the primary elements of science, its creative aspect, is seldom recognized in the classroom much less made the subject of instruction. Science is fundamentally, though not exclusively nor mainly, a creative activity as evidenced in its typical involvement with hypothesis formation, hypothesis testing, and communication of ideas. Yet its creativity is not usually recognized by students who often have difficulty transforming the vocabulary and facts presented to them into a personal understanding of the natural world and of the nature of science itself.

Knowledge provides potential fuel for creativity, but it is the imaginative use of knowledge that is essential for the production of new ideas. As I. I. Rabi (1970) expressed it, "Science is a liberating art that helps us deal with reality consciously rather than by tradition and by rote" (p. 46). Teaching techniques are needed that can strengthen the students' abilities to interrelate their knowledge or better yet, that can provide a vehicle for personal synthesis that leads to understanding and a framework for the solving of as-yet-unforeseen problems.

Where might such teaching begin? Is there some common element in creative thinking that lends itself to direct instruction?

Bronowski (1965) stated that the act of creation can be generalized as being the discovery of a new unity in the variety of existing experiences, or "explosions of a hidden likeness." Eyring (1959) has provided specific examples of "an exciting variety of creativity--the recognition of analogies" in modern chemistry and W. J. J. Gordon (1974) has collected many reports from the history of science of clear cases of associative analogical connections acting as the cause of theoretical breakthroughs in science or of technological innovations. Mathematics began, according to Bertrand Russell (1927), when it was discovered that a brace of pheasants and a couple of days have something in common: the number two. But that commonality had no prior existence in the physical world. It is a relationship produced in the mind by freely selecting a similar feature while ignoring others that are quite dissimilar.

Drawing an analogy where there is none before is to provide a model or matrix for achieving a new insight. It is an operation of intellectual power to connect emotional, logical, and aesthetic elements into new wholes. It is a metaphoric equation-making in which neither side directly implies the other (Arieti, 1976; Bronowski, 1958; Koestler, 1964; Yukawa, 1973) and by which one transforms past experience in order to furnish a number of different possibilities for the present situation (Raaheim, 1974).

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Making connections or analogies is believed to be an important part of the creative process. The odds that original and relevant connections with personal meanings may arise out of the students' science-related experiences are thought to be significantly increased when either heuristic discovery or student-initiated inquiry is encouraged (Suchman, 1977).

Study Description

At the time of this study done at the University of Iowa, the "Foundations in Science" program had a problem-solving design which Suchman would call heuristic learning. (See Table) Problems or questions to consider were presented to students via printed activity sheets, work materials were put at their disposal, and in absence of an algorithm or rule, they had to find ways to proceed. The teacher was available to listen to ideas, to encourage experimentation, and to ask challenging, extending questions. Students themselves decided when the investigations were completed and satisfactory solutions were ready to be communicated in written reports.

Table

Relationship of Teaching/Learning Strategies to Problem-solving

Type of Problem-solving	Problem	Rule	Solution	Strategy
None	Given	Given	Given	Lecture
Deductive	Given	Given	Not given	Guided discovery
Inductive	Given	Not given	Given	Guided discovery
Creative	Given	Not given	Not given	Heuristic discovery[a]
Creative	Not given	Not given	Not given	Inquiry

[a] Primary strategy used in Foundations in Science

The whole focus of Foundations' classes was on manipulation of materials, observations of their reactions and limitations, and attempts to find relationships that describe or explain the phenomena noted. Overt control by the teacher was minimized in what was fundamentally a student-centered laboratory experience. Direct teaching using lecture, precise directions, and teacher-initiated evaluations was rarely used, and learner initiative in experimentation was given priority over "look it up" or "recall what the teacher said." This type of allowance for self-instruction in absence of both rules and "right" answers, but within parameters of a prepared environment, has been assumed to favor creative problem-solving (Suchman, 1977). Then would there be a further increase or a reduction in student creativity if learners were encouraged to share ideas via brainstorming and to practice using analogies?

The primary purpose of this study was to determine whether learning about one aspect of creative thinking, the development of analogies and metaphors related to general science, would stimulate creativity of selected undergraduate science students. A secondary aim was to measure whether the hands-on experiences alone would increase creativity of college-age students in a basic science course.

Creativity was defined as a problem-solving process by which statistically rare solutions are produced and measured by the *Torrance Tests of Creative Thinking*. Comparability of the four undergraduate classes involved in this study was established by assessing student aptitudes for creative and academic work with a pretest, the *Alpha Biographical Inventory* (Institute for Behavioral Research in Creativity, 1968). A *measure of Student's Self-perceptions in Science* was also used to indicate any changes in attitude toward science as an activity. Trained observers used Shymansky and Penick's *Science Laboratory Interaction Categories* (1979) to record classroom behaviors of the teacher and the students, providing evidence of their similarities.

A pretest, posttest, control-group design was used, involving 72 undergraduate women planning to be elementary school teachers. All were enrolled in one of four sections of general science laboratory classes featuring student-centered activities. The same trained teacher coordinated all four classes. The experimental groups only [N = 37] experienced interruptions of Foundations activity time in order to get brainstorming instructions and occasional group practice in developing analogies during the six week duration of the principal part of this study. The control group spent class time exclusively on "hands-on" Foundations activities.

In making analogies, students manipulated their points of view or context in attempts to achieve new or more complete understandings. The procedure was simple, though capable of great elaboration. Confronted with a problem (to integrate and understand new observations or new perspectives), one would ask, "What is this like?" in a deliberate search for fresh comparisons. A "mystery powder" became a carefully wrapped Christmas present; a supersaturated solution was likened to a carnival crowd; a pendulum became a one-armed monkey, a spider on a thread, a park swing; chrysalids were compared to kernels of popcorn.

Done in group sessions, taking turns, students found that ideas sparked other ideas and a quantity and quality of expressions resulted. Judgment was always delayed until everyone had made contributions and suggestions. But then, just as important as making the initial analogies, there was critical discussion later of what was and what was *not* fitting about them, and attempts were made to reconcile the differences. The greater the distance between halves of an analogy, the greater mental flexibility was required to incorporate both frames of reference with respect to a single object or idea. Also, both divergent and critical thinking were eventually involved in the process of drawing new comparisons that could result in greater understanding of unfamiliar concepts and phenomena.

Students also viewed a short movie made by Canadian students (Hodges, 1975) in which personal analogies to behavior of solutes were developed and enacted by a chemistry class.

Results

Analysis of covariance of the *Torrance Tests of Creative Thinking* with the pretest as a covariate showed a significant difference ($p < .001$)

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in verbal creativity in favor of the experimental group which had learning-by-analogy experience. The outcome suggests that creative performance can indeed be stimulated by practice in analogical thinking.

Both experimental and control groups significantly increased their scores on figural creativity ($p < .001$). Opportunities for manipulating class materials without restrictive teacher directives may be credited for the gains. Lack of a control groups for Foundations classes as a whole makes this conclusion somewhat tentative, but the result does parallel that observed by Penick (1976). In that study, fifth-graders exposed to a student-centered learning environment where youngsters had freedom to use given materials according to their own styles of investigation also showed increases in figural creativity over a comparison group who followed the teacher's explicit directions when handling science equipment.

Student's perceptions of their own activities in science, both before and after Foundations' experience, showed a dichotomy in orientation toward science as an activity. When the pretest items on Self-perceptions in Science (adapted from SPS-II by Shymansky, et al., 1974) call for personal involvement by the student--"What would you do?"--more students preferred to wait for directions from the teacher or peers that to initiate an activity. Experience in Foundations classes shifted responses toward to most active, independent mode of problem-solving. However, nearly all of the students initially viewed the scientist's (third party) role in inquiry situations to be an active, independent one, an opinion that changed little. Thus the pretest, in particular, supports the observation that some students have a "split-perceptual view" of the problem-solving aspect of science, a view that shifts depending whether problem-solving is a personal challenge or whether it is an expert's preoccupation. Three months of Foundations experience seems to have reduced this ambivalence. A significant number of students ($p < .01$) had increased confidence that they could uncover basic information on their own initiative (Simonis, 1978).

Discussion

The most significant difference between the experimental and control classes was the verbal creativity scores on the TTCT. Even though the treatment was of short duration (approximately eight sessions spaced over six weeks time), some effects seem to have lasted at least the remainder of the semester. A cooperative class spirit of sharing ideas that did not impede doing activities individually; spontaneous eruptions of brainstorming sessions among three to four students at times when faced with puzzling or seemingly inconsistent observations; use of analogies to amplify explanations in some of the final reports; and relative facility in completing a "Science is like ... " statement two months after treatment ended were small but positive indicators of prolonged effects.

Given evidence that creativity can be stimulated by the use of analogies, educators should incorporate analogy-developing thinking strategies into educational curricula. Giving students examples of useful analogies and encouraging them to develop their own examples in idea-sharing sessions is a simple and inexpensive method. Yet, it can improve acceptance and assimilation of unfamiliar concepts. During idea-spurring sessions, the teacher must be a willing listener, rather than a lecturer, allowing more student communication and student initiative. Opportunities should be provided for students to demonstrate, practice, and strengthen their own abilities to relate new knowledge to former experiences and to match lab observations with less-controlled "real world" happenings. As Moravcsik (1981) has stated, "A feeling of self-reliance, a desire to play the role of an initiator and a self implementer, must be an essential part of truly functional and creative science education."

Brainstorming is a particularly interesting vehicle for sharing and developing ideas. The emphasis on a free flow of ideas and making combinations or additions while all judgment is suspended allows many more suggestions to be expressed than when evaluation is expected immediately. But critical thinking, although deferred, is also necessary to reach conclusions and make decisions on the implications or appropriateness of ideas proposed. This could be considered a model of the complementarity of creative and critical thinking, a relationship that should be examined by science students and be illustrated, demonstrated, and modeled by science teachers in particular.

Piaget has already made science educators aware of the importance of object manipulation and a diversity of concrete experiences to the development of logical thought. Data collected in this study show that figural creativity was also significantly increased by the hands-on activities that are the heart of a Foundations' class. The ability to complete and interpret geometric shapes in various ways on Torrance's tests was also correlated to academic success in this laboratory-oriented experience (Simonis, 1978).

The interactions between development of logical thinking and of creativity should be explored since both are needed for scientific pursuits and for effective education. The context-dependent nature and affective component of some forms of creative thinking, including use of personal metaphors and analogies, has been noted by many writers and psychologists. However, I think that such strategies may be quite useful, especially as "bridges" between familiar experiences and ideas and the abstract principles that are identified with science. The ability to creatively instruct oneself by using and developing verbal analogies seems deserving of explicit encouragement, especially for "science-shy" young women. I hope that there will be more efforts to explore the use of analogies and I expect that a better understanding of these will illustrate differences between thinking persons and thinking machines.

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Teachers' differential treatment of girls in technological education

A celebration of diversity?

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Summary

In a study of 10 schools for Senior Technical Training (4 year courses) we discovered differential treatment of teachers towards girls. In interviews with girls and teachers and in a pupils' questionnaire a lot of extra attention for the girls showed up and sometimes a different sort of marking of their work.

The girls -a small minority in these schools- dislike this extra attention as much as the higher and the lower markings they get.

In our project we try to put this across to the teacher in team-gatherings.

1. Backgrounds and design of the study.

In the Netherlands the MENT-project is charting the position of girls in Senior Technical Training (STT). STT is vocational education for pupils of 16 to 20 years old.

In this article we would like to lift out one part of this research, viz. the behaviour of teachers towards girls and boys.

There are very few female pupils in Senior Technical Training, but their number is growing (figure 1). The attitude of teachers towards boys and girls has been investigated before, but this was always done at schools with about as many boys as girls. In that case it appeared that girls get less attention from the teacher than boys (Spender, 1982; Stanworth, 1983). In view of the experiences of women in 'male' professions one may suppose that at schools where there is a minority of girls, other processes are going on than at mixed schools. The odd woman working between many men is extra visible and has to put up with more than usual attention (Kanter, 1977; Ott, 1985). This extra attention may sometimes have positive effects, but mostly women consider it to be extremely unpleasant.

In the investigation we checked what the effects of this other or extra attention are at schools where there is a minority of girls (1.5%). In the gathering of data we confined ourselves to 3 large sections of STT that occur frequently and where few girls are present: Electrical Engineering, Construction- and Mechanical Engineering. At the 10 schools we visited we each time talked to 10 teachers (100 in all) and to all girls from the aforementioned sections (a total number of 83). We also used a questionnaire about emancipation, girls and technology in 4 classes of each school. 886 boys and 10 girls filled out this questionnaire. The interviews took place in the schools. To prevent the time-table from being disturbed too much we tried to confine the duration of the interviews to 1 lesson (50 minutes). Most of the time this worked well because of the relatively strict scheme for the interviews. The conversations were recorded on audio-cassette and worked out later on. After this the data have been encoded to make a meaningful description possible. The inter-judge-reliability, calculated in the way Weesie and Brummelhuis (1986) described, was 0.85.

2. Teachers' attitude towards girls and boys in class.

a. Pupils' questionnaire

Two theses about teachers' behaviour towards boys and girls were taken up in the pupils' questionnaire. The pupils could give their reactions on a five-point-scale. 54% of them agreed to the thesis 'A girl at STT usually gets more attention from teachers than a boy'. Only 2% said that boys get more attention.

33% of the pupils does not agree to the thesis 'If a boy fails to understand something he will sooner be helped by a teacher than if a girl fails to understand something': the pupils think that a girl is helped sooner. Only 0.5% says that a boy will be helped sooner.

b. Teachers about themselves.

In the interviews with teachers we put several questions which may bring up a different approach to girls. One question was: 'Sometimes girls at STT get the impression that teachers mark their work in a different way from boys' work: Do you yourself have a feeling sometimes that you mark girls' work different from boy's work?' In case of an affirmative answer the next question was: 'In what way do you mark girls' work differently?'

34 Teachers say that they (tend to) discriminate in the marking, 61 say they do not do this, and 5 are not sure.

64 Teachers, either on request or not, gave some explanation: 30 times there was a tendency to be more flexible in marking, because of the exceptional position of girls in STT (10 times), their better tidiness and motivation (10 times), their less technical experience (3 times), and without comment (7 times) respectively.
Only 3 people had the feeling that they marked girls' work more strictly, whereby two teachers did this to prevent boys from objecting to 'favouring' of girls. Some indicated that they did not mark the work differently, but that they did pay some extra attention to girls, for example by checking whether they really understood the subjects that had been discussed (6 times), whereas two others mentioned that they were less coarse to girls than to boys in pointing out that they made a mistake or behaved wrongly.
12 Teachers said that they always marked the work irrespective of persons, for example by not looking at the names.

Whether this other marking is experienced as positive or negative by girls, may depend on the way this is done and what the backgrounds of such a different marking are.

Some quotations to illustrate this:

". . . I mark the work more positively, I suppose, she has got it wrong because she has to get used to things and is extra nervous, she is simply handicapped because she is a girl. Just like someone who returns from hospital after some time, then too you think, he'll just have to get used to things. Just have a look. Maybe you are reading more positive things between the lines than there actually are".
(teacher of construction engineering).

"Sooner positive discrimination than negative discrimination, but I try to check it, girls work more neatly, this has a positive influence, that is normal. There are girls who deliver a fabulously neat piece of work. It is also a condition for a technician to arrange and formulate things well. In general girls pay more attention to this than boys do. This comes out in their marks. This is not inherent to the fact that it is a girl, but they do this, there are also boys who do this: boffins, fiddlers, who write out everything very stricty." (teacher of mechanical engineering).

Unless the work is marked more positively because it is more neatly, which is a legitimate aspect in marking, one may posit that a more lenient marking usually works in an unfavourable way. Soon there will be the message behind it, even though it is not meant this way, that girls are not as good in technology as boys are, or that they are marked for being a girl, and not for their work. This does all but stimulate their self-confidence. Then girls will not have any clear feedback about their actual strong and weak points for that subject.

Teachers were also asked: 'There are only few girls on a school for STT, this always makes them a bit conspicuous; Do you yourself have a feeling sometimes that you pay different attention to girls than to boys?

45 Teachers say that they sometimes have a feeling that they pay a different kind of attention to girls, 53 teachers deny this and 2 teachers do not know. When asked for an explanation of their answer this other kind of attention appears to be mainly in the field of content of the subject (15 times), because a girl at STT is an exception (18 times) and that in some cases there is an evident, or suspected, need for support, for example if the girl is not accepted by her fellow-students (9 times). There are also 11 teachers who say that they approach girls in a more friendly way, among other things by adapting their own usage or by making more allowances in case of disturbances. For 8 teachers the male-female aspects appears to play a role as well in their different approach: 'You can't help looking at them with pleasure', according to a teacher of mechanical engineering. The answer of 32 teachers could be interpreted as follows: A girl is a pupil like any other and thus I will treat them the same way. A female teacher in physics gave the following explanation of this: 'For a year I have studied at the Technical High School here because I did not want to leave this province, but I left for misery because you attract so much attention. I hated it. In those days there were very few girls, anyway. Maybe I dislike this so much (attracting attention, ed. AA) that I simply treat them as human beings: boys or girls makes no difference to me!
Recapitulating we may conclude from these data that the reports of the teachers and boys about different treatments are in agreement. By the way, there is no difference in the marking of girls'work between teachers who have experience in mixed education and teachers who have worked in 'boys' education' only. In both groups of teachers about 33% say that they tend

to make a distinction, meaning that they are more lenient with girls. Apparently the teachers' attitude depends more on the situation 'extremely few girls in class', than on his or her experience in teaching to mixed groups.

Finally we would like to go into a subject that is extremely appealing to imagination viz. 'disturbance of the order'. The teachers were asked about girls and boys respectively whether they would do something that the teachers considered to be annoying. We also wanted to know how they reacted to this annoying behaviour of girls and boys respectively. Among the reactions to annoying behaviour (mainly chatting and not paying attention to the lecture), we found several sex-specific to sexist remarks. Some quotations:

'Chatting (annoys me) . . . (I react to this) just like with boys: say that they have to be quiet. I think that I sometimes relate this to them being women, that this shows in the terminology I choose. I think I am likely to do this.' (language teacher).

'In one class there are 2 girls who are nattering sometimes. I think this is typical girls' behaviour. When they are annoying there is a reason for it, that is not to make fun. (reaction). I use, for example, the phrase' we are not here to have tea together'. I know very well that this remark is discriminating. When boys are being a nuisance, I say to them 'We are not in the F-side here' (an often misbehaving soccer-fanclub). This remark is not so striking as the other one but it is in the same sphere' (language teacher). There is a situation, though, that in general teachers' reactions to annoying activities of girls are somewhat more lenient than to the same activities of boys. Boys appear to get more 'severe' reactions (punishment, sarcasm, being sent away) relatively more often than girls. By more lenient reactions we mean: ignoring, making a neutral remark, trying to draw their attention to the lecture (subtly). For girls a severe reaction merely means sharp comments, whereas boys are sometimes sent out of the classroom or are given a great deal of lines.

c. Girls about teachers.

In the interviews with the girls we asked the question: 'Are there any teachers who treat boys and girls in different ways?'

69% of the girls confirmed this, but even more girls (76%) gave examples of differences. As could be expected on the basis of literature on working women in minority positions, and the answers of the boys, not even one girl mentioned that she got less attention from teachers: 1 girl had heard a rumour that girls of the year before wanted to get more attention. This was brought in against her at the moment that she protested against the extra interest in her well-being.
A number of girls (7) mention things that could be called 'the placing at a disadvantage of girls'. For example a quotation from a girl in first grade construction: 'There are teachers who very consciously clash with the girls, give her extra negative attention of fear of favouring the girl'. In this respect giving lower marks to girls is mentioned twice.

However, much more examples of extra attention (22) and favouring of girls (25) are given by the girls. A number of girls has doubts about the honest marking of tests. Neither favouring, nor the extra attention is considered positive.

Quotation:

'When they explain something they often say: 'Do you understand it also?' As if a girl is a few years younger and this does not go without saying! (third grade construction).

'I do not like it. The reactions of boys to favouring is that they will shut you out from the class'. (third grade construction).

It is alarming that 11 girls, in reply to this question, give examples of more or less sexist remarks made by teachers. The fact that this occurs more often became evident from other questions, where again other respondents came up with anecdotes about similar sexism of teachers. A number of times it is said about teachers that in class they talk more or less seriously about the women's task being the household. Other teachers try to motivate the class by pointing out that 'even the girls are better' and still others do not accept the presence of girls:

'Some teachers like it (girls in class) and others do not. Last year a teacher said: I do not understand at all what you are doing at this school' (third grade electrical engineering).

Only 6 girls consider the different attitude towards girls to be positive. The majority denounces it, but 32% can understand it, though. They doubt whether they have to blame the teacher for it. He has to get used to it as well, that there are suddenly girls in class, they tend to say, trying to make things seem better.

Conclusion

As appeared very clearly from our research-material, there is a group of teachers that treats girls so different from boys, that it strikes the attention. Girls are very much annoyed by this. Sometimes, when teachers become aware of these processes, this leads to a different attitude. As it was formulated by one teacher:

> 'I heard from Rianne: in Junior Technical Training she got fed up with the fact that she got so much attention. Therefore I paid special attention to this, to make sure I would not do that!
> (teacher of physics).

Now, what we try to do is to present this research to as many members of the teaching staff as possible and to raise the discussion and conceptualization thereby.

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Are the girls the problem? Gender and computer-science in the Danish secondary school-system.

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The following is a presentation of a research project I am carrying out under the above title. The title is intended to suggest - in a polemic way - that the girls are not the problem when the topic is gender and computer-science. The problem is the content of the subject and the power-relations determining this content. In this paper I will give a brief presentation of some of the theses, theories and empirical research upon which the project rests.

Thesis on gender and computer-science.

The point of departure for my project is that girls and women do, in fact, go into information-technology - they actively seek computer skills in order to adapt towards a changing society and labour-market. About 40% of all pupils choosing computer-science in the secondary schools (1) in Denmark in 1985/86 were girls. (2) Computer-science in the secondary schools is an optional subject which the syllabus defines as a broad subject consisting of the following areas: communication, information and data; problem-solving with the use of computers; applications for computers and their implications.

There is an apparent tendency for the number of girls and women in computer-science to increase when the content of the subject is organized closer to the humanities and social science than to mathematics and physics. This tendency is clearcut at the university level.(3)

It is on this basis that I pose the thesis that computer-science must leave room for learning-processes which contain possibilities for gaining a wider social and humanistic understanding of the applications and implications of information-technology in order to attract and maintain the interests of the girls. This approach must also take cognizance of the class background of the girls even though the role of class is difficult to define. This thesis is predicated upon a theoretical approach towards the definition of information-technology as necessarily involving both technical and social science dimensions if it is to create a so-called technological understanding.(4)

The class dimension.

Girls and women do not only act as gender but also as members of differing social classes or strata. The gender-identity of girls (and boys) are formed by the social background within which they are born and this influences their perception of their future possibilities. I believe that the difference in class determines where one see oneself placed in the power-relations of society. A girl from a working-class or educational underpriviledged background generally will tend not to expect to become an executive or a manager whereas this possibility in much less remote for a middle-class girl. In other words working-class pupils tend to see themselves in less powerful positions contrary to middle-class pupils. These different perspectives could influence their attitudes towards computer-science.

Working-class pupils from social backgrounds which do not

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give priority to education will, I propose, tend to be more interested in the technical and formal part of computer-science whereas pupils who are not alien to education will be able to cope equally with both the technical and the technological - and hence debatable - aspects of computer-science. This relation is suggested by the results of research on the connection between social background and mathematics which shows that pupils from educationally deprived environments tend to choose the mathematical line in high-school and not the linguistic line, which demands knowledge of upper-and middle-class culture from the outset.(5)

. Present educational policy.

Contemporary educational policy in Denmark is aimed on the one hand at providing technical labour-power to an industry- and service-sector which competes internationally on the basis of technical know-how, and on the other hand at strengthening what is called the "common core" of subjects which is seen as being mainstays of Danish culture.(6) If my thesis is correct, this strategy will not provide the basis for creating a technological understanding - or a creative and independent labour-power. If technical skills are not taught in such a way that they envolve social and cultural issues, they risk loosing the interest of the girls.

The girls are particularly important in this connection because an important goal of educational policy is to change the direction of their education from the female dominated service, social welfare and healthcare sectors which lead to public employment, to the now male-dominated technical sectors which lead to private employment. And the mean is not to change the girls but the content of the subjects.

Theoretical approach and empirical background.

Gender and class socialization are often treated separately or as two social categories with the same meaning. But the connection between gender and class are much more complicated - gender is a lifelong constant characteristica while a person can in some ways change her or his class identity through education. Gender and class act together but exactly how is both a theoretical and an empirical problem that remains to be solved.

There is a greater emphasis on gender than class in contemporary pedagogical research.(7) This might be because the meaning of class for young people is diminishing as some English research suggests.(8) It might also be because the dominant theoretical approaches to class are to rigid for use in a society where the industrial working-class is rapidly diminishing and being replaced by an expanding service-sector, with so-called white-collar workers.(9) The gender aspect of the equation, on the other hand is more clearcut. My theoretical approach to the issue of gender builds upon a version of psychoanalytic theory.(10) I use this theory mainly to understand - and explain - why technological develoment is culturally and historically male-dominated.(11) That is why there exists what one could call a common consciousness determining men to be in supreme power of technological development.

The empirical research which I draw upon when I argue that girls are more motivated to study computer-science when the technical content is presented in a wider societal and

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humanistic context derives mainly from research on gender and the study of physics in the schools.(12) The same conclusions are suggested, however by research on women in engineering.(13) Furthermore if one examines research on women and office-automation there is a similar tendency for women to direct their interest in information-technology towards use and purpose related issues, whereas men confine their interest more to the process of manipulating the tool itself.(14)(15)

Research-design.

The project is a piece of so-called qualitative research as I intent to analyze how the meaning of gender and class act together in the specific context of the subject computer-science chosen by pupils in the secondary school. Can equity of class and gender be achieved in the learning processes of computer-science? Can technical skills and technological understanding become integrated parts in the learning-processes?

An important part of my reseach-design is to cooperate with teachers who from the outset are interested in the gender aspect - and who actually finds it challenging to change their learning-processes in favor of the girls. I have made contact with two female teachers who complies with my requests.

I have so far been doing class-room observations in one of the teacher's computer-science classes - that is one 8th grade and one 9th grade computer-science classes. I have also been an observer in a few 8th grade lessons in mathematics. This has taken place in the autumn of 1986. In the spring of 1987 I will continue to do class-room observations in these classes plus do individual interviews with some of the pupils. Futhermore I will do some class-room observations in the other female teacher's 8th grade computer-science lessons also in the spring of 1987.

The class-room observations has so far involved educational courses in electronical registration, a game and electronical wordprocessing. The teacher has deliberately avoided to start up with doing programming in order to illustrate the many applications of computers. She has by doing so tried to meet the needs of the girls. However she probably now halfway through the school-year has to change her strategies as the boys (who are in the minority) are very unsatisfied and want to stop having the subject.

When I do class-room observations I concentrate on gender-differences in behaviour. I write extensive notes on the basis of following either the whole class are one or two pupils at the computer. I try not to intervene but when the pupils ask me something I will help if I can. The following research results are a summary of my notes prepared in the light of my theoretical point of departure.

Preliminary research-results.

During my observations in a class where the theme was electronical registration I saw only the image of girls and boys which I expected. I saw the conscientious girls who claimed to be there in order to qualify for the job-market. In the course-evaluation they said that they felt they had learned from it, although all I saw was bored girls during the course. The boys were there for fun - they wanted to learn how to do programming and make their own games. They claimed that the course was too long and that they had not learned anything. It

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was also typical that the girls were eager to participate in discussions on the social implications of living in a society with lots of registers but it was difficult to have these discussions because the boys obstructed them with noise and destructive behaviour. There was no room for discussing the hopes and fears of the girls. The discussions tended to end in chaos and the computer or other individual or group-exercises served as a means of establishing disciplining.

When this topic in registration was completed we made a double-lesson in which we, at request of the boys, as a Christmas-treat, allowed the pupils to use the computer to play games. The girls were, in the beginning, not very eager to do so and the boys were passively obliging. The game had very clear roots in the boys' and men's world of play as the object in the game was a car. It has been constructed by a father and his two sons who were a little younger than the pupils in the class.

By the end of the lesson the girls were actively engaging in the computer-game. Some of them had changed the car into a kind of a space-object, they made it jump crazily around the screen, gave the car and the screen lots of different colours etc. They were laughing and in control of the game. They had asked and asked - tried and tried the silly program and they ended up having a fun lesson. The boys, on the other hand quickly gave up and started, on their own initiative, to make very easy small programs in BASIC. They did this very quietly. We discovered that they had given up on the game in the very beginning. It was as if they did not want to ask neither us nor the girls. I felt they were ashamed feeling that they were supposed to be superior and therefore not to ask any questions.

Further questions and research.

I do not want to jump to any conclusions on my preliminary observations as I have too little data to build upon. But I feel that my theses on gender have been put into question. My observations raise questions about the girl´s own perception of the learning-processes in the game-lesson. Did they learn anything? What did they perceive as the content of the learning-processes? Was the game a means to approach the technological issues related to computer-science? Or do they only think of this learning-processes as beeing a purely technical exercise? These questions plus, of course, the questions related to social background (e.g. socialization plus the girl´s future plans in connection with their interests in computer-science) can only be answered through future interviews.

Notes:

1) That is 8th grade pupils of 14-15 years old.

2) Peter Stjen Jensen: Datalære i folkeskolen. In: Uddannelse nr. 10, 1985.

3) Vibeke Høeg m.fl.: Kvinderne kan ikke lide lugten i bageriet. In: Nordisk Datanytt nr. 1, januar 1986.
For further discussion of this aspect see also:
Bente Elkjær: "Det er så kedeligt og irrelevant..." En diskussion af et konkret ligestilllingsprojekt i forbindelse med undervisning i informationsteknologi. (a) Arbejdspapir no.10, Institut for Informatik, DLH, Cph. 1986.

4) Hans Siggaard Jensen og Ole Skovsmose: Teknologikritik - et

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teknologifilosofisk essay. Systime, Cph., 1986.

Bente Elkjær: "The New Technology is Women's Opportunity..." (b) In: Women Challenge Technology. European Conference on Women, Natural Sciences & Technology. Contributions vol. 1, Eslinore, 1986.

5) Katrin Hjort: Pigepædagogik-? Pigerne ved overgangen fra folkeskolen til gymnasiet. Gyldendal, Cph. 1984.

Preben Marker: 1. g. 1978-79. Undervisningsministeriets Økonomisk-statistiske konsulent: Uddannelsesanalyser. Cph. 1979.

6) Bente Elkjær: Kvalifikationsudvikling og ligestilling. (c) Arbejdspapir no. 12, Institut for Informatik, DLH, Cph. 1986.

7) There are exceptions, see e.g. Harriet Bjerrum Nielsen & Kirsten Larsen: Piger og drenge i klasseoffentligheden. En analyse af pigers og drenges deltagelse i klasseundervisningen på 1. og 3. klassetrin. Pedagogisk forskningsinstitutt, Universitetet i Oslo 1985. Bjerrum and Larsen offer us perhaps an explanation of why there is a greater emphasis on gender than class as the gender-contrast is more conspicuous than the class-contrast in school. The class-contrast however becomes more noticeable when comparisons are made within each group of gender.

8) Palle Rasmussen: Arbejdsløshed og ungdomspolitik - belyst ud fra unges situation i en engelsk industriby. In: Unge Pædagoger nr. 8, december 1986.

9) David Hogan: Education an Class Formation: the pecularciarities of the Americans. In: Cultural and Economic reproduction in Education. Essays on Class, Ideology and the State. Michael W. Apple. (Ed.) Routledge and Kegan Paul. London 1982.
E.P. Thompson: The poverty of theory: or an orrery of Errors. In: E.P. Thompson: The poverty of theory an other essays. Merlin Press, London 1978.

10) Dorothy Dinnerstein: The Mermaid and the Minotaur. Sexual arrangements and human malaise. Harper and Row, N.Y. 1976.
Bente Elkjær: Patriarkatet som en flugt fra modermagten - en præsentation af Dorothy Dinnerstein. In: Patriarkatsteori - en antologi. RUC, Roskilde, 1984.
Bente Elkjær: "Vi frygter alle kvinders vilje og magt" - et bud på en anden måde at tænke teknopatriarkat. In: Forum for Kvindeforskning. Nr. 4, 1985.

11) The question is of course if gender-characteristica common for all girls and women still are being produced as this theoretical approach is connected with mother-dominated child-care which has to a large degree been taken over by institutionalized childcare - which of course also is female dominated.

12) Svein Lie og Svein Sjøberg: "Myke" jenter i "harde" fag? - om realfag og likestilling. Universitetsforlaget, Oslo, 1984.

13) Anne Bruvik-Hansen og Yvonne Due Billing: Ærlig talt. Forskningsrapport nr. 6, 1984. Institut for Samfundsfag på

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14) Kirsten Thomsen m. fl.: "...Men vi grinede mere dengang". AQUA-projektet - om kontorautomatiseringens konsekvenser for kvinders beskæftigelse, kvalifikationer og arbejdsmiljø. Kvinder på Tværs, RUC, Roskilde, 1984.

15) I do not think that computer-science is strictly comparable with physics because information-technology is not a natural-science. (See Jensen og Skovsmose 1986, op.cit. and Elkjær 1986(b), p.cit.) Futhermore the era of information-technology is, to a much larger degree than earlier technologies, characterized by a public debate. New concepts have derived from the era of information-technology e.g. technological valuation, user friendly, technology-aggreement etc. There is a more comprehensive common consciousness of the implications of new technology and there is a possibility for both pro and con positions.

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Does that Train Set Matter? Scientific Hobbies and Science Achievement and Choice

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Abstract

This paper uses data from the Girls Into Science and Technology (GIST) project to explore the link between children's early hobbies and experiences and their later achievement in and choice of scientific and technical subjects at school. At first sight it looks as though girls who have more experience of scientific activities are more likely to choose to continue with scientific subjects when these become optional. But children from advantaged home backgrounds have both greater experience of scientific activities and a greater likelihood of continuing with scientific subjects. When this is taken into account there is still a slight tendency for girls who have spent more time in tinkering activities to take more technical craft subjects at school, and to achieve better in physics. But these relationships are very small, and in general there is little connection between pupils' early experience and their subject choice and achievement. This may be an optimistic finding as it suggests that girls' under-involvement in science and technology cannot be blamed on parents but has to be accepted by teachers as an educational problem.

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Does that Train-Set Matter?
Scientific Hobbies and Science Achievement and Choice

Introduction

Boys, more often than girls, are given train-sets for Christmas. Boys' playthings are more frequently mechanical or electrical. Boys are more often encouraged to help around the house with odd jobs involving tools. Feminists (and others) often attribute girls' later avoidance of scientific and technical activities to this early socialisation. Boys have more experience than girls of tinkering activities and this may make them feel more at home in the science laboratory or the craft workshop. In turn the girls may feel strange in these environments, and so chose not to prolong their stay, once physical science and technical crafts cease to be compulsory subjects at school.

So much is speculation. But I am not aware of any research that demonstrates a link between early out of school experiences and later subject preferences. One way of looking at this is to examine the experiences and choices of individuals. Some individual girls have participated extensively in tinkering activities, and some individual boys have not. Are their subject choices affected by their experiences?

Data

I want to attempt this analysis using data from the Girls Into Science and Technology (GIST) project. The project has been described in detail elsewhere (Kelly _et al_, 1984; Whyte 1986), and I will only outline it here.

GIST was an action-research project which worked with teachers to devise ways of encouraging more girls to chose physical science and technical craft subjects when these became optional. Simultaneously we researched the reasons for girls' avoidance of these subjects. We worked in ten co-educational comprehensive schools in the north of England. Children entered these schools aged 11, and made their subject choices three years later, at the age of 14. The GIST project followed a cohort of approximately 1700 pupils through these three years.

In England each school can, and to a certain extent does, organise its own curriculum. This makes it difficult to generalise. However the most common pattern in the ten schools we studied was for all pupils to be taught combined science in mixed ability sets for two years after entering secondary school. In the third year most schools divided science into the three subjects of physics, chemistry and biology, which were taught seperately. Craft subjects were generally taught in a 'circus' for the first two or three years. All pupils, both girls and boys, spent a block of time (perhaps eight weeks) studying a subject such as woodwork; they then rotated and spent the next block of time on another subject such as technical drawing while another group took their place in woodwork; the first group would then move again, perhaps to cookery; and a fourth block of time might be spent on needlework.

During their third year all pupils, in consultation with their parents and teachers, had to decide which subjects they were going to study for the remaining two years of compulsory schooling. These courses lead to public, external examinations. Schools generally offer twenty to thirty subjects, from which the pupils have to choose seven or eight. Again patterns differ, but in general all pupils have to take maths and English; often some physical and some social education is also compulsory. A craft subject may be recommended. Many schools insist on one science, but try to discourage pupils from taking all three science subjects.

A number of questionnaires were given to the GIST children in their first term at secondary school, when they were eleven years old. One of these was a Scientific Activities questionnaire. This contained a list of forty two different activities which had some scientific or technical content. The children were asked to tick a box by each one to indicate whether they had done it 'quite often', 'once or twice' or 'never'. The items were then grouped into scales, using factor analysis. Three scales emerged: TINKERAC, which contained items about using tools, making models and finding out how machines worked (i.e. tinkering); BIOLSCAC, with biological activities such as visiting a farm or looking at different parts of a flower; and THEOSCAC with more theoretical and academic activities such as reading a book about science, looking at the stars or working out inventions.

The items and the scales are discussed in detail in an earlier paper (Small & Kelly, 1984). Strong sex differences emerged on all the scales and on many of the items. Boys had much more experience than girls, on average, of tinkering activities. Girls had more experience than boys of biological activities. The differences were least on the theoretical scale, where neither sex had much experience, although boys were slightly ahead of girls. Interestingly, many of the 'pure' science activities, such as 'play with a magnet to find out what it will pick up' or 'play with a magnifying glass' did not load on any of the scales.

Results

In this paper I am not so much interested in the items or the scales themselves as in their relationship to later achievement in and choice of scientific and technical subjects. These are explored in Table 1 which shows the correlations between pupils' scores on the Scientific Activities scale and their choice of and achievement in scientific and technical subjects at the end of third year (when they were fourteen years old). All ten schools offered physics, chemistry and biology (and/or human biology) in fourth year, so choice of these subjects is simply a dichotomous variable, chosen or not chosen. However the availability of technical craft subjects varied widely between schools. The variable shown in Table 1 is a summary measure, the total number of technical craft subjects taken. This varied from three to zero. Achievement is measured by results in the end-of-year school examinations. In several schools no such examinations were held in technical craft, or the results were not available to GIST, so these correlations are only shown for science subjects. Even in science the results are incomplete, especially for biology, where the total number of students for whom data was available was reduced to 899.

Table 1 shows that among boys experience of tinkering activities was virtually unrelated to either achievement or choice of scientific and technical subjects. However there was a small but consistent tendency for girls who had engaged in such activities to be more likely than other girls to continue with scientific and technical subjects; they also achieved slightly better than other girls in physics. Girls' participation in biological activities was also weakly related to both

Table 1. Correlations between Scientific Activities at age eleven and choice and achievement in scientific and technical subjects at age fourteen

	Girls			Boys		
	TINKERAC	BIOLSCAC	THEOSCAC	TINKERAC	BIOLSCAC	THEOSCAC
Subject choice						
Physics	.14***	.20***	.24***	.05	.08	.16***
Chemistry	.10*	.15**	.15***	.01	.06	.18***
Biology	.13**	.19***	.17***	-.03	.03	.07*
Tech craft	.11**	-.02	.07*	.03	-.09**	-.17***
Achievement						
Physics	.09*	.08*	.08*	.00	.04	.22***
Chemistry	-.01	.11***	.08*	-.05	.02	.25***
Biology	-.07	.06*	.05	-.09	.08	.21***

* correlation significant beyond the 5% level
** correlation significant beyond the 1% level
*** correlation significant beyond the 0.1% level

choosing and doing well in science. However for both sexes the strongest relationships were with theoretical science activities; boys who had engaged in these activities before they entered secondary school achieved considerably better than other boys in science at the end of third year, and were more likely to continue with science subjects into fourth and fifth year. On the other hand they were less likely to continue with technical crafts. Girls who had engaged in theoretical science activities were also more likely to continue with science when it was no longer compulsory, although they did not achieve markedly better than other girls in science.

One of the problems with a simple correlational analysis like this is that both factors may be caused by a common third factor, rather than having any intrinsic relationship to each other. In this case it is possible that children from middle class homes both engaged in more theoretical science activities and achieved better in science, simply because their home background was conducive to such activities and achievement. A composite variable, HANDICAP, has been developed to represent a child's home background, based on parental occupations, IQ at age eleven, number of siblings, cultural activities in the home, and academic record of the school (see Kelly, 1987 for details). Correlations between this variable and the variables representing

Table 2. Correlations between scientific activities, choice and achievement in scientific and technical subjects and the composite background variable, HANDICAP

	Girls	Boys
Scientific Activities		
TINKERAC	.09*	.02
BIOLSCAC	.25***	.15***
THEOSCAC	.17***	.30***
Subject choice		
Physics	.38***	.46***
Chemistry	.30***	.40***
Biology	.13***	.08*
Technical craft	-.05	-.34***
Achievement		
Physics	.67***	.61***
Chemistry	.64***	.66***
Biology	.65***	.61***

* correlation significant beyond the 5% level

** correlation significant beyond the 1% level

*** correlation significant beyond the 0.1% level

scientific activities, subject choice and achievement in science, are shown in Table 2. It is clear that achievement in science was very highly correlated with home background. There were moderate correlations between home background and participating in biological and theoretical science activities, and between home background and choosing physics and chemistry. However participation in tinkering activities and choice of biology were only weakly related to home background. Among boys there was a negative relationship between HANDICAP and choice of technical craft, indicating that it was more popular among boys from less advantaged backgrounds, but for girls these two variables were almost unrelated.

The relationships between scientific activities and subject choice and achievement, controlling for HANDICAP, are shown in Table 3. The pattern of correlations is much reduced from that in Table 1. When children from the same sort of home background are compared it makes very little difference to their subject choice or their science achievement whether or not they have engaged in scientific activities while at primary school. A few of the correlations do reach statistical significance, but they are based on large numbers, and none of them are sufficiently large to have educational or social significance. There is

Table 3. Correlations between Scientific Activities at age eleven and choice and achievement in scientific and technical subjects at age fourteen, controlled for background variables

	Girls			Boys		
	TINKERAC	BIOLSCAC	THEOSCAC	TINKERAC	BIOLSCAC	THEOSCAC
Subject choice						
Physics	.06	+.03	.00	.06	.01	.04
Chemistry	-.02	.05	.03	-.01	.00	.09*
Biology	-.08*	.05	.03	-.04	.02	.06
Tech craft	.13***	-.01	.06	.07	.05	.07*
Achievement						
Physics	.13**	-.04	.10*	.03	.09	.04
Chemistry	.07	-.02	.02	-.07	.09	.08
Biology	.08	.03	.04	-.10*	-.03	.07

* correlation significant beyond the 5% level
** correlation significant beyond the 1% level
*** correlation significant beyond the 0.1% level

a slight tendency for girls who had experience of tinkering activities before they entered secondary school to be more likely than other girls to continue with technical craft subjects and to achieve well in physics. But these relationships, although the largest in the Table, were still extremely small.

Conclusion

So does that train-set for Christmas matter? From this analysis the answer would seem to be 'not very much'. Girls who have some experience of handling tools, playing with mechanical toys and generally tinkering are slightly more likely than other girls to choose to study technical craft when this becomes optional at school and to achieve well in physics. But they are no more likely than other girls to continue with physical science. And even the statistically significant correlations are so small that it is difficult to make them the basis for any recommendations.

I find this an optimistic outcome. It suggests that the problem of girls' under-achievement in science and technology is not essentially one of early experience, and that solutions should not be confined to this level. In this way itt lessens the burden of guilt on individual parents. If you didn't give your daughter a train set for her fifth birthday, you haven't ruined her chances of becoming a scientist for ever! Of course its important to encourage little girls in scientific and technical hobbies, but its not the end of the road if they don't respond at home.

This argument has only been made at the individual level. It may still be that adolescent female culture precludes an interest in mechanical things because, collectively, young girls do not engage in tinkering activities, and that this cultural prohibition is more powerful than individual experience. The societal dimension cannot be neglected. But changes must also be made in the way that science is taught at school, and in the way that subject options and career opportunities are presented. This will not be easy to achieve. But it is possible that it is easier to change the professional practices of teachers than the child-rearing practices of the population at large. As a first step it is important that teachers 'own' the problem as an educational one, and cease to blame parents for the failings of the educational system.

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THROUGH THE LOOKING GLASS OF A SWEDISH SCIENCE TEACHER

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SUMMARY

In spite of Sweden's equal opportunity programme policy science and technology remains male dominated. The project described wants to find out girls' views on science and technology and careers in those areas. Thirtytwo pupils are being followed from the start of grade 7 in the compulsory school, when they are 13 years, until they make their choice for the upper secondary school in grade 9. The project is now in its second year. The main interests lies in the interactions patterns in the classroom and in the science curriculum but the pupils are seen in a wider context. This paper presents a description of six of the pupils based on interviews, observations and a questionaire. It is suggested that science and technology are introduced in a less favourable period in life for the girls compared to the boys and that more effort should be put into changing the school and the school science rather than trying to change the girls.

BACKGROUND

In the Swedish comprehensive school all pupils begin to study science (biology, chemistry, physics) and nowadays also some technology in grade 7. The studies continue through grades 7 - 9, the lower secondary school, when the pupils are 13 - 15 years. It is not possible to opt out any of the subjects. A common curriculum core is looked upon as a means to achieve equal opportunity for all pupils. During grade 9 the pupils decide which of the 23 lines in upper secondary school they want to choose. At present more than 90 % of the pupils continue secondary school.

In spite of Sweden's well known reform policy striving to promote equal opportunity even concerning gender the options to the upper secondary school are to a great extent gender-bound and the girls choose science and technology much less frequently than boys. There have been several campaigns and action programs, mainly in order to persuade the girls to choose less traditionally. Some progress is made but the sexual division of both the upper secondary school and the labour market remains strong (Statistics

Sweden 1986).

The egalitarian or state feministic measures are not sufficient as they do not take the general subordination of women and the structural injustices in society into account (Kelly 1985, Spender 1983, Weiner 1985). Other strategies are needed. According to my teaching experience we have to focus on the girls in order to develop a girl-centered education, instead of trying to change the girls. In an earlier study (Staberg 1985) I found differences between the girls in grade 7 and grade 9, indicating that many girls lose their curiosity and interest in science during the lower secondary school. That was the incitament for the present study. This paper wants to give a glimpse of this ongoing project, now in its second year. The project is funded by the National Board of Education.

THE PROJECT

My aim is to find out the girls own view of their situation and attitudes to science. I continually study two groups of pupils from grade 7 until they make their choice in grade 9. Several techniques are used, mainly qualitative; classroom observation, interviews, questionaires etc.

The main interest are in the interaction pattern in the classroom and in the science curriculum. However I find it important to place my observations in a wider context. The pupils' experiences outside school, their relations to their parents and friends, attitudes to the other sex and not least their growing maturity are in my view very important.

My study is a project within a Nordic network, called the HEKLA project, which tries to look at the effects of education reforms on the life and work of women. All studies within the HEKLA project use a "life-line perspective" developed at the institute of Education in Umeå (Elgqvist-Saltzman 1987).

The HEKLA project uses a common theoretical framework where the concept rationality is central. Norweigian sociologist have in studies of paid and unpaid labour found two different forms of rationality, a "technical limiting" and a "responsible" rationality (Ve 1982). I want to find out if this concept is helpful in explaining the different thinking of girls and boys concerning science and career choice. Do the girls see science and technology as male enterprises? Do they see careers in these areas irrelevant for them (Benckert/Staberg 1984, Keller 1985, Sjøberg 1986,

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Whyte 1986)? The concept may also be useful in explaining the interaction system in the classroom.

This paper presents a description of six children based on observations, life-lines written in the beginning of grade 8 and quotations from interviews made in grade 7.

THE PUPILS

There are 34 children in my study. In this paper I have chosen to highlight three girls and as a background three boys. The three girls represent different academic ability and different attitudes to science and technology.

Below you will find a short description of the six children and a graph where I have put together their responses to the "life-line question". That is, they were presented with a time axis and asked to mark for them important events on the axis.

Sara comes from a family with academic traditions. She is one of the dominant pupils, she gets a lot of questions and also puts questions, often very good ones, but she does not shout out. Sara is confident and constructive and not afraid to ask for explanations. During experimental work she is interested and eager, especially in chemistry and her notes are correct and concise.

Maria is a quite and ambitious girl. From the beginning extremely unsure of herself. She has now gained some confidence. She is not much noticed in the classroom, but considered very reliable. This has consequenses, eg has one of the boys in order to calm down been placed together with Maria and her friend. Her insecurity shows during lab work when she often seeks fault with her own work. Consequently she often asks the teachers for advice. Her notes are neat and correct but can be unnecessary detailed.

In contrast to the other girls, Pernilla wears quite a lot of make up and jewellery. She dresses strikingly and is very preoccupied with her appearence. She is rather silent during frontal teaching, but makes notes and tries to follow. Her lab work is very good, she is especially fast with technical tasks. Her notes sometimes show that she has difficulties with the theory.

Krister and Martin are pals. They work together and are both interested in science, Krister being the brighter one. He makes a lot of comments, especially in physics lessons, supplementing the teacher, showing off knowledge of electricity, motors and so on. Both boys tend to laugh or boo when one of the clever girls makes mistakes or asks questions. During experimental sessions they are eager and often fiddle with the equipment after they have completed the given task, which leads to a shortage of time for notemaking and theoretical questions. This is in contrast to the girls, who,at least in physics, quickly finish the experiment in order to work with book problems.

John and his mate are often in the back row, they seldom listen to the teacher or participate in the lessons, although John makes more effort than his friend. They have difficulties with the experiments as they can not or will not follow written instructions. John tries to find out what the girls in front are doing and to copy their notes. The teachers found his result on written tests much better than they expected.

CUTS FROM THE INTERVIEWS

Boys who are our ages they are more like children in a sand-box... (Sara).
They are so childish (Pernilla about boys of her own age).
Pernilla, she likes boys who take snuff, have mopeds and are in grade 9 ...
Around the sixth or seventh she and her friend became a little coquettish ...
then they started seeing older boys (Krister).

According to my observations the girls are at the beginning of lower secondary school much more mature than the boys, more responsible, more articulate and even more ambitious than the boys. This higher responsibility and ambition are sometimes criticised by the boys. They complain or are noisy when the girls asks for clarifications or sneer at their diligence. But some girls fight back.

The boys may understand sometimes to the extent that they do it mechanically but we want to know all ... It doesn't matter to them, but to us it matters if we don't understand! (Sara).
Girls are swots (John).

In the life-lines (see graph) Pernilla tells about her boyfriend and Sara about friendships and travelling without grown ups. Martin and Krister mention their cats, but otherwise write about traditional male objects and endeavours. This preoccupation with things also shows in their comments to science and technology.

I think physics and chemistry are most fun. There are so many things (Martin).
Physics and chemistry is fun, to connect and do things (John).
Computing was fun ... but those computers were horrible (Krister).
Technique Lego, we still do it, to go up to it. There are engines, gear-wheels, differentials ... (Krister and Martin about their spare-time).

The girls talk more about understanding, as shown also in the quotation from Sara above. But they also enjoy the experiments,especially in chemistry.

There is a lot you might understand ... but I don't remember it (Pernilla).
I like it because I understand (Maria).
And the current, where does it come from? What makes it go round? (Sara)
What I enjoyed were the experiments ... I always like experiments
(Pernilla)

The three girls have different attitudes to girls' and boys' aptitude for science and technology, Sara being the only one whose reaction finds room for protest. She realises the existing division of labor

If she (Pernilla) was a boy ... she would become a mechanic on the spot
(Sara).

but is irritated when she feels that some boys believe that boys on the whole are better than girls. Pernilla, who herself are very good at tinkering activities has the opinion that boys are better.

Boys know more (about technology) ... It is natural, I think (Pernilla).

Maria has very low self-esteem, at least concerning her ability for science. Even before she began secondary she had the idea she would not make it.

I thought it would be very difficult ... I thought I would never make it, but I feel more confident now (Maria).

Even for her physics and technology are more suited for boys. Although her results often are better than Krister's are and because Krister talks a lot while she is silent, she says

Krister is good at physics and technology ... I suppose boys are more interested in such things (Maria).

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Responses to the request to mark important events on a time axis

Age	Maria	Pernilla	Sara	John	Krister	Martin
7	Started school	Started school	Played with Marcus Began playing with Elsa	Started school	Started school Got a cat	Started school
8					Drove a tractor	
9		Got my first hamster Got another hamster	Began playing basket Stopped playing with Marcus		Got a moped Started elementary school	Got a cat Got a moped
10			Read my first book for adults		Got another moped	
11			Elsa moved. Began to be with her other friend,Anna			Drove a tractor for the first time
12	Got a hamster	Began lower secondary	Began lower secondary	Began lower secondary	Took part in the elkhunting with daddy	Bought an air-gun
13	Began 7th grade	Became a teenager. Started seeing my boyfriend	Went to Stockholm on my own with Anna		Drove a car	
14	I am not yet 14					Pulled out a tooth 21/8 -86

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DISCUSSION

In the HEKLA project it is found that the higher educational reforms to a great extent have been made for a young man without a family. I would suggest that with aspect to science and technology the compulsory school is more suited to the boys' development. I have not yet much data but will test my hypothesis further.

It is often said that we should compensate the girls for their lack of experience with certain toys and for an alledged lead of the boys. I do not find these girls disadvantaged to boys in general. Some boys have acquired a knowledge of different objects and a technical vocabulary but this is compensated by the girls' ability to follow an instruction, to make proper notes and to cooperate. Many girls are also good at handling lab equipment.

More important to me is if the school does not give the girls the opportunity to develop their full potential in science and technology. Girls and boys are in different phases of life when these subjects are introduced. It seems to me that the girls should benefit if the subjects were introduced earlier. Now they may have lost a couple of receptive years and at 13, many of the girls are also preoccupied with their growing maturity.

In this paper there has not been room for a discussion of the science curricilum. We know from other studies that girls and boys value different aspects of science. It seems clear to me that we should make our efforts in changning the school and the school science rather than trying to change the girls when we want more women into science and technology. These fields ought to be less characterized by the technical limiting rationality and more by the responsible rationality if they were less maledominated.

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WHY ARE MANY GIRLS INHIBITED FROM LEARNING SCIENTIFIC CONCEPTS IN PHYSICS ?

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ABSTRACT:

We describe the kind of difficulties facing students and specifically girls, when comprehension of new scientific concepts and physical reasoning are required. It is shown, that the response of students to such difficulties is dependent on a complex of interacting cognitive and affective factors, and it is suggested that girls and boys through socialization develop different styles of learning. As a consequence we propose some changes in the traditional style of teaching physics.

INTRODUCTION.

This article will be based on the results of our ongoing work in cooperation with Sussanne Blegaa and Mette Vedelsby in the research project: "Sex-roles and physics education - an analysis of the sex-polarizing effect of the subject". We are teachers of mathematics and physics, and the project deals with students in the Danish Gymnasium (upper secondary school, age 16-19).

GIRLS AND PHYSICS - A PROBLEM IN THE DANISH SCHOOLSYSTEM.

It is generally experienced up through the educational system that whenever it is possible girls choose the stream or branch with maximum physics less frequently than boys do. The actual situation in the Danish upper-secondary-school and higher education is illustrated in fig.1. Although the girls at a certain level have passed a harder selection, it is evident that the transition-frequency of girls is persistently lower than that of boys.

The upper-secondary school ("gymnasium") is attended by abt.1/3 of the 16-year olds. The pupils can choose the mathematical side or the linquistic side (without physics). After the first year, they have to choose between different branches. On the mathematical side one branch (called mF) includes high-level

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courses in both math and physics, while several other branches have physics at lower level. As is seen from the figure, 25% of the "mathematical" girls in contrast to 50% of the boys choose the high-level mF-branch. The later choice of higher education with high-level physics (Technical University of math/physics/chemistry at university) shows still stronger sex-polarization.

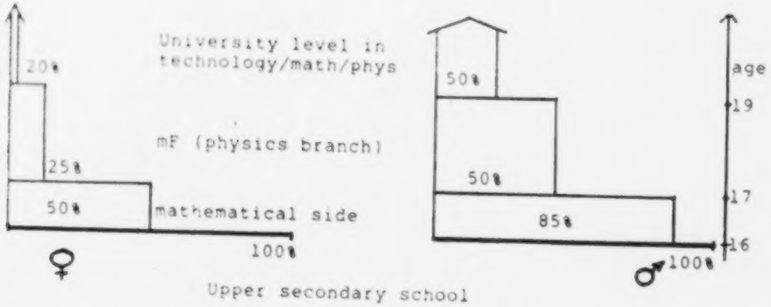

Fig.1. Schematic illustration of girls' and boys' affinity to high-level physics. The numbers are transition-frequences from one level to the next.

Sex-differences are not only found in patterns of choice, but also in relation to performance. Girls get significently lower marks for written examinations in physics in upper-secondary schools as well as at the technical university. Sex differences in mathematics are smaller.

A consequence of this is an underrepresentation of women in education and occupations involving physics or technical subjects, and this problem is receiving much public attention in Denmark these years.

In contrast to the early discussions about sex-roles and education, it is now widely accepted that physics has a stronger sex-polarizing effect than other school-subjects. This fact was recognized relatively late in Denmark, partly due to the limited number of physicists engaged in educational research. The dominant Danish tradition for research on general problems of pedagogy and education is affected these years: Several research-groups have emerged, concerned with specific problems of one subject, and with basis in the concrete teaching-practice.

We are members of such a group engaged in a project: "Sex-roles and physics education". Our background is university-degrees in physics and mathematics, and several years of teaching experiences. As female physicists we are "exceptional" persons, and we gain an important strength from the cooperation in the joined research-project. In addition, each of us is involved in different ways in public debates, in developing teaching material and in seminars for teachers, guidance councellors, researchers, educational-politicians etc.

INTRODUCTION TO OUR PROJECT.

In our project we have focussed on physics-teaching and the pupils' response to it in the upper-secondary school, the mathematical side. Our purpose is to throw light on the general and subject-specific factors responsible for the extreme sex-polarizing effect of physics education. At the same time, we want to suggest how teachers and schools could work to reduce this effect.

We are fully aware of the fact that school-systems and education are only part of the mechanisms responsible for the prevailing sex-roles in society.

We have followed three classes (abt.80 pupils) of their first year of upper-secondary school. We have collected information on the lessons and the pupils' response in narrow cooperation between the teachers of physics and mathematics for each class and a permanent observer of this class from the project-group. The observer has watched most of the lessons of physics and math during the year and on a few occations she also attended the class in other subjects.

We have tested different sequences of teaching in cooperation with the teachers of the class. The pupils' written reports on experiments and their answers to problems, tests and special questionnaires have provided us with supplementary information. Furthermore, the observer interviewed all pupils in "her class" once or twice (in small groups) and we made a limited follow-up-study in the second year, after the pupils had chosen their branch. We have primarily used qualitative methods, and in our work we obtained a detailed knowledge of each individual pupil. We believe that this procedure is necessary as we wish to examine the influence on teaching and learning of

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the interaction between affective and cognitive factors.

Teachers should pay more attention to this interference between feelings and knowledge, and she/he might create a more girl-friendly climate of learning, by changing the style of teaching. Suggestions of this kind are stated in the paper of our colleague (1) to this conference.

Another contribution (2) deals with the subject-matter of physics-teaching. It describes consequences for the motivation and learning of girls and boys, of organizing the content in themes (in contrast to the traditional disciplines of scientific physics).

In the present paper the authors try to explain the well-documented fact, that the sex-differences in science are particularly pronounced when problem-solving ability or understanding of concepts and theories in physics are investigated. The special character of physics together with sex-specific socialization, seems to result in differences in learning-style and in horizon of interests between boys and girls - in relation to this subject.

SEX-DIFFERENCES IN LEARNING CONCEPTS AND PHYSICAL REASONING.

Physics is more than other school-subjects, characterized by a high number of scientific concepts, by a mathematically formulated basis of theory, and by experiments to be interpreted in the light of theories and models.

The Danish teaching in physics presumes an ability of abstraction which is not really present with a major group of students. Consequently, physics is conceived as (one of) the most difficult subjects in school. The most difficult aspects, it seems, are even more difficult for girls than for boys, and this phenomenon can not be sufficiently explained by the different practical experiences of girls and boys. Girls are doing well and they like to work with experiments in areas which are not based on earlier teaching. Nevertheless, there are difficulties whenever exact physical reasoning or problemsolving is required.

In our experimentation with theme-organized curriculum (2) which should increase the motivation of girls, we had the hope of improving the process of theory-learning and problem-solving as well. We did experience a growth in motivation of both boys and girls. But in cases where we expected the students to explain every-day-phenomena using physical concepts (e.g. latent heat of melting, absolute and relative humidity) we were disappointed.

One part of an explanation for this is related to the students' idea of the demands: the broad presentation of the problem produces expectations of general every-day phrases as a valid answer.

A majority of the students feel no need for clarification of concepts as required in physics, and they have no imagination as regards the value of scientific explanations in contrast to every-day descriptions. - For these reasons they present a spectrum of "explanations" ranging from nonsense to indications of analogies.

A few relatively bright boys and girls felt that the realistic context of the problems caused disturbances. They preferred "pure physics problems" and they felt more secure in the well-known framework with usual formulas.

This last mentioned reaction may point to another part of an explanation: It is simply difficult to apply physical concepts and reasoning. Despite the higher motivation resulting from the broader and more realistic context, the problem-solving is not any easier. On the contrary, it is even more difficult to formulate or reformulate a problem by discarding some of the presented information. The problem should be changed from the original verbal.form to a form involving the relevant physical concepts and their relations. After the emergence of a set of equations, more students (including girls) can do the problem. Usually the problem is not mathematics in itself, but the formulation of a model through simplifications and valuations.

Very often this process of curtailment seems rather arbitrary to the girls. Boys are more ready to play the game as expected, while girls tend to be affected more seriously by the problems in their full complexity.

Some times girls are more engaged in problems of relevance for mankind and environment, but at the same time they might be inhibited from obtaining the scientific knowledge and tools necessary for them to treat this kind of complex problems seri-

ously.
It is important to be able to change consiously between different ways of looking at the problem: On the one hand the problem should be acted on in its full complexity, and on the other hand one should be able to reduce the perceived problem in different relevant ways to simpler problems which can be treated, using well-known methods and theories.
If the latter method is refused, the good intentions might be lost in details and the result is lack of comprehensive view. On the other hand, the easy reduction without concern for the complexity of problems has often shown its insufficiency. This is often seen in technical solutions too, for example environmental problems, where important aspects of the problems have been omitted.

SEX-RELATED LEARNING-STYLE.

Girls are defensive in their reactions and characterised by a fear of making a fool of themselves. In contrast, the boys are more offensive, they are compelled by an urge to achieve. This sex-difference has been described by many authors. In our own work we have seen it in various ways, besides the wellknown difference between boys' and girls' behaviour in class. Like others (3), we have seen that girls have a tendency to evaluate their own performances lower than do boys. Finally, there is a difference in the way that girls and boys meet a challenge, and that plays a major role when they are in the process of learning new concepts. *We think that girls and boys develop different styles of learning (4). Therefore girls are often inhibited from obtaining success in the parts of physics that have a theoretical basis.*

In the teaching of physics, importance is attached to scientific concepts, some of which have a rather different meaning from the equivalent concepts in everyday life (e.g. heat, energy, work, force). The learning of such concepts does not take place by simple assimilation, but it requires the student to live through a crisis to bring about a reorganization of the cognitive structure (accommodation). This process is accompanied by a feeling of insecurity, and it implies a readiness to take risks for which the teaching of physics seldom prepares the students.

Girls generally feel that they must have a thorough understanding of a subject before they can go on to a new one, whereas boys do not mind going on to new problems before they have thoroughly understood the old ones and that way of learning gives good results in the long run. The girls will, to a larger extent than the boys, seek security by trying to do what they think is correct, that is, what they think that the teacher expects them to do. That results, to a large extent, in rote learning, and they do not get a general view of the subject.

Both parents, teachers and friends will readily accept a girl saying that she does not understand physics. The fact that the surroundings do not expect the girls to understand physics confirms the girls' own belief that they don't.

The girls are thus socialized to have very little confidence in their own abilities in physics, and partly as a consequence of that, they have less positive experiences with the described learning processes than do the boys. Furthermore the girls often consider learning physics irrelevant.

When the students are asked to describe their lives as they expect them to be as 30 years old, it is characteristic that the boys have only formed clear ideas of their job situation (and they think that their knowledge of physics may become useful in that respect). The girls have clear ideas of their whole life situation. They have precise ideas about husband and children, about their dwelling and whether they will have a full-time or a part-time job. The girls visions of the future is thus to a large extent characterized by their relations to other people. Education and job only fills part of the picture. They do not allow professional ambitions to fill out all fo their lives.

Firstly the girls do not experience physics as particularly relevant to themselves, and therefore they are not inclined to continue when the difficulties grow too great. Secondly, as mentioned before, the girls react in a more negative way to the insecure situations that precede the acquirement of really new understanding. The girls are hampered by these feelings.

Through our interviews we learned that the boys also often dis-

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like working with formulas in physics, but often they perceive it as a challenge, and they go through with it, even when they feel insecure. Many boys are convinced that physics will be useful in their further education and in their leisure time.

The different styles of learning of girls and boys is thus influenced by an interaction between cognitive and affective factors.

PERSPECTIVES FOR ANOTHER STYLE OF TEACHING.

The learning style of girls is thus characterized by less self-confidence and less perseverance, because they believe physics to be of little use to them. It is therefore essential to organize the teaching around subjects that motivate girls as well as boys (2). Other changes, however, are equally necessary.

It is necessary that the teacher makes an effort to make the students aware of the learning processes and of the existence of possible blockings (1). The teacher must explicitly explain how the learning of a quite new concept takes place gradually. She/he may perhaps illustrate how she/he has experienced how the understanding of a concept already learned has been improved and become more detailed later on. Learning/understanding develops gradually by using the concept.

The formation of new concepts requires certain preparations. The students' eyes must be opened to the phenomena/relations that are to be described, and they must learn to name the relevant patterns. A "potential of meaning" must be formed as a basis for the new concept. Therefore, the teacher must accept and appreciate analogy explanations, as a necessary stage in the abstraction process that leads to new understanding. Although, after all, we want the proper scientific physical explanation of a phenomenon, we must get into the habit of accepting and rewarding correct analogy explanations (e.g. "When the smoke from the chimney is more visible in the winter time, it is just as your breath is white, when it is cold").

Progression in the teaching must be increased gradually and more slowly than is usual in the Danish Gymnasium. Furthermore it is essential that the teaching allows every student to learn something, but on different cognitive levels according to the capacity and the needs of the individual student. This is to a large extent actually the case in other subjects than physics. In, for example, the subjects on Danish lanquage and litterature and social science, abstract scientific concepts are also used, but in these subjects phenomenology and personal experiences are important parts of the work, and a mastering of these aspects of the subjects is rewarded. It means much to a student to know that she/he is not a total failure, although she/he cannot meet all the demands. A part - fulfilment of the demands must be recognized as a part - success and be rewarded accordingly.

Physics is probably the subject in school which most clearly informs the students of their failures. The teachers, therefore, must be made aware of the capabilities of the students, and on the basis of that knowledge they must convey to the students a realistic spectrum of expectations. Obviously, this is a difficult process, and the teacher will make mistakes, but mistakes of that kind are especially fatal in physics, as girls only tolerate few fiascos in that subject. On the contrary, girls have a special need to experience successes in that subject.

As a conclusion, we want to emphasize that in our view the important challenge to the physics teachers is to recognize the sex-differences in learning style and to change their traditional style of teaching in the way described - without going to the opposite extreme.

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GENDER AND SCHOOL SCIENCE: A CASE STUDY

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Introduction

Gender differences, favouring males, have been found on standardized achievement tests, not only in Canada (Bateson, Anderson, Dale, McConnell & Rutherford, 1986), but world-wide (Kelly, 1978). However, such differences are generally not found in school science achievement. The inconsistency between standardized test results and course grades has been recognized in both science and mathematics (e.g., Bejar & Blew, 1981; DeBoer, 1984; Levin & Fowler, 1984; Maccoby & Jacklin, 1974; Zarega, Haertel, Tsai & Walberg, 1986). Most of the research on gender and science achievement has attempted to identify factors which may be related to, or responsible for the underachievement of females on standardized tests.

A number of recent classroom studies have reported that teachers interact more with boys than with girls in science and mathematics classes (Becker, 1981; Fennema & Peterson, 1986; Sadker & Sadker, 1985; Whyte, 1984). Some have suggested that this differential treatment may, in part, account for at least some of the observed differences between males and females in science achievement. However, this paper will focus on the inconsistency between the two types of achievement for girls and will look to the classroom, in an attempt to identify some gender differences in how students approach their learning.

Method

The study was part of a larger study whose broad purpose was to investigate the relationship between students' prior beliefs and the learning which occurred during a grade nine (14 to 15 years old) science unit about heat and temperature. One aspect of the overall study involved the contrast between learning "correct answers" (as measured by school science grades) and learning with understanding (as measured by a posttest, developed and described by Shayer and Wylam, 1981). Details of the instruments and methods have been described elsewhere (Haggerty, 1986).

The posttest provided a measure of understanding of the concepts, whereas the unit test measured factual knowledge which could have been rote learned. It was anticipated that the results of the posttest would be comparable to standardized test results, in that both measure understanding of concepts rather than rote learning. If this were so, then it could be expected that the girls would do as well as the boys on the unit test, but not on the posttest, and that gender differences on the posttest would be greatest on the higher level subscales.

Results and Discussion

This paper will summarize the quantitative findings of the study and will draw on the qualitative data to offer some possible explanations for the findings.

Research has shown that boys participate in class activities and discussions to a greater extent than do girls (Sadker & Sadker, 1985; Whyte, 1984). In this study, gender and talk were significantly related, with males talking more than females. In mathematics classes, Becker (1981) found that boys were questioned more frequently than girls, and that they were asked more higher level questions. Fennema and Peterson (1986) found that teachers interacted more with males than females, regardless of whether the interaction was student or teacher initiated. In this study, the relationship between participation in class dialogue and gender of student was consistent with Becker's and Fennema and Peterson's findings. Boys participated proportionally twice as often as girls.

A very interesting distinction emerged when talk was correlated with the different measures of achievement. Pretest scores and school science grades were not significantly related to talk. However, a different picture emerged for the posttest scores. Total posttest scores and Level 2 and 3 subscale scores (but not Level 1 scores) were significantly related to amount of talking ($r=.57$, $p<.01$; $r=.64$, $p<.01$ and $r=.47$, $p<.05$, respectively). Similarly, pretest/posttest gains were significantly related to amount of talking ($r=.49$, $p<.05$). That is, there was a significant relationship between participation in class discussions and both success on higher level questions on the posttest and gains from pretest to posttest.

Boys' and girls' scores on the achievement measures were compared. Differences on the pretest were approximately one-half of a standard deviation, not a significant difference. However, boys clearly outperformed girls on the posttest, with a difference of one standard deviation. Most of the difference was accounted for by the higher level subscales, particularly Level 2. School science grades were not significantly different for males and females, although on the unit test, boys did outperform girls. Midterm and final course grades were essentially identical for girls and boys. These grades were based on both test marks and marks obtained for assignments. Thus, it was when marks for assignments were included with test marks that the girls' performance was equivalent to that of the boys.

Analysis of covariance (with the pretest and talk as covariates) showed that when adjusted for the effects of the covariates, boys' posttest scores on higher level questions were greater than girls' scores, whereas on Level 1 questions girls did slightly better.

A striking pattern between gender, talking and pretest/posttest gains was identified when gains by individual students were examined. It has been noted that there was a significant relationship between gender and success on Levels 2 and 3 of the posttest. Eleven students gained four or more points in the Levels 2 and 3 combined subscale scores. Nine of those 11 were the boys in the class. Only two of the 14 girls gained four or more points. They were also the two most talkative girls in the class (together they accounted for 43.1 percent of the talk by girls).

Some students who did poorly on the posttest did very well in school science. Conversely, the student who was most successful on the posttest barely passed the course. This suggests that some who were successful in school science must have relied on rote-learned knowledge, and then have been unable to apply that knowledge to the unknown situations presented on the posttest. Without exception, such students were female. The student who was very successful on the posttest, a male, did not appear to be very concerned about school achievement.

Observations of student behaviour during classes may shed some additional light on the gender differences. In class, boys asked question proportionally more than four times as often as girls. When girls did ask questions in class or individually, they were usually concerned either about the right answers to questions, or the accuracy of their experimental data. The girls who showed the greatest inconsistencies in school science and posttest achievement were conscientious about completing assignments and getting correct answers. If experimental findings were different than they had anticipated, the girls seemed to be annoyed. The boys, on the other hand, were intrigued by the unexpected and often tried "mini-experiments" (which the girls tended to call "fooling around") to investigate unexpected results. These observations are reminiscent of Kahle, Matyas and Cho's (1985) findings that males reported doing more science activities in school than did the females who were in the same class.

Gender differences were also observed with respect to homework and notebooks. Girls rarely came to class without their homework completed and ready to hand in for grading. Their notebooks were well organized. Several boys rarely submitted assignments. When they did so, the work was often only partially completed and very untidy. A number of studies have reported similar gender differences in behaviour and work habits in school science and/or mathematics. Callahan (1979) and Walberg (1969) have suggested that girls more than boys are rewarded for being docile and well-behaved, although such behaviour is dysfunctional in school science. In two studies based on self-report data, DeBoer (1986) found that females reported that they work harder than did boys, and Zarega et al. (1986) noted that girls reported doing more homework than did boys. Maccoby and Jacklin have suggested that girls success in mathematics courses is due to "greater effort, greater interest and better work habits" (1974, p. 135).

Some boys appeared to understand the concepts, but be unwilling to memorize school science facts and definitions which were meaningless to them. A particular example was the boy who had the highest scores on both the pretest and posttest. He was frequently late for class, his behaviour was often disruptive, he rarely handed in assignments and when he did, they were incomplete and untidy. He missed several classes and did not make up work he missed, even when there had been a test in his absence. Although he was often inattentive, he did appear to enjoy science activities. During laboratory activities he was a model student, expressing curiosity about the activities and the reasons for the phenomena observed. He also was the only student to indicate any curiosity about the purpose of the study or the data that were being collected.

Summary

In this paper it has been noted that although females do as well as males in science course achievement, on standardized tests males regularly outperform females. This study found the same inconsistency between the course grades and the posttest scores. Moreover, a comparison of school science grades and pretest and posttest scores revealed that it was not necessarily the students with the highest grades who showed either the greatest gains from pretest to posttest, or the highest scores on the posttest. The teacher-made unit test emphasized knowledge which could be rote learned, whereas the pretest and posttest required that students apply their knowledge to new situations. Boys and girls did equally well in school science and on lower level posttest questions, but boys outperformed girls on higher level questions. Gains in scores from pretest to posttest were greater for boys.

Boys participated in class discussions more than did girls and they demonstrated a more active and inquiring approach to laboratory activities. Girls appeared to be more concerned with meeting the teacher's expectations with respect to providing correct answers and completing assigned tasks. The findings of this study illustrate the value of looking beyond statistical analyses, to examine the behaviour and characteristics of individual students.

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ADVANCED LEVEL PERFORMANCE IN THE SCIENCES IN SINGLE-SEX AND CO-EDUCATIONAL JAMAICAN SCHOOLS.

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INTRODUCTION

Over the past two decades or so, the movement toward co-education has been on the increase internationally, and Jamaica has, not unexpectedly, followed this trend. In recent years, however, there have been indications from a variety of sources, that the merits derived from educating boys and girls together seem to be offset by certain negative factors, chief among these being the stereotypic perspective which steers girls away from challenging and difficult subjects such as the sciences, toward the so-called "easy options" (Note 1). While data concerning the actual performance levels of students in different types of schools (single-sex and co-educational) have been conflicting, it has been established by the present writer that, at least at grade 11 of high school (one of the two terminal points of secondary schooling) students of both sexes attending single-sex institutions out-perform their counterparts in the co-educational setting, especially in the sciences (Note 2). This study did not, however, explore achievement at the second terminal point of departure from high school (grade 13) which, in the main, determines which students, based on their performance in the General Certificate of Education (GCE) Advanced Level examinations set by Cambridge University, will obtain university matriculation (typically to the University of the West Indies) (Note 3).

The aim of the present investigation, therefore, is to explore the trend established previously for grade 11, at grade 13 by examining the performance level of Jamaican students in the GCE Advanced Level science examinations on a school type basis.

Jamaica follows the British pattern of high (secondary) school education, in that, at the end of five years' secondary schooling, students sit the GCE Ordinary Level examinations and/or the Caribbean Examination Council's (CXC) examinations which are, basically, patterned off the GCE. Those students who have performed creditably at "O" Levels/CXC may be permitted to enter sixth form (grade 12) where two years' further study prepares them for the GCE Advanced Level examinations (taken at grade 13). Success in these examinations virtually guarantees them admission to universities such as the University of the West Indies: into the science-based faculties (Natural Sciences, Agriculture, Engineering, and, if their grades are very high, the Medical Sciences); the Arts faculty (Arts and General Studies); and the Social Sciences or Law faculties.

METHODOLOGY

Data for the present investigation were collected for the 1985/1986 base year (students sat "A" Levels in June, 1985, for admission to university in the 1985/1986 academic year), at which time some 40 institutions (excluding private and evening schools) entered candidates for this examination. The sample of schools selected was as follows:

Boys' Single-sex Schools	7
Girls' Single-sex Schools	- 9
Co-educational (boys' and girls')	- 22
(Total	- 38)

The relevant information was gathered from the Cambridge Syndicate's local branch office on an individual student basis per science subject, and a record was also made of the particular school entering each student for the examination. GCE "A" Level results are reported as grades, ranging from A (distinction) to E (all five categories representing passing grades), O (an "Ordinary" Level pass) F (a failing grade) and X (indicating that the candidate had failed to appear for the examination). In all, data were collected for 1,877 candidates, the breakdown by school type being as follows:

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Table 1

DISTRIBUTION OF CANDIDATES BY SCHOOL TYPE

School Type	No. Sitting "A" Levs.	% Total Candidates
Boys' Single-sex	389	20.7
Girls' Single-sex	428	22.8
Boys' Co-ed.	548	29.2
Girls' Co-ed.	512	27.3

THE FINDINGS

It was ascertained that 1,051 of the 1 877 candidates were entered for at least one science subject, while only 667 of this number could be considered "true" science students (that is, having entered for 2/2+ science subjects). It was also noted that male candidates (from both single-sex and co-educational institutions) were best represented in the sciences (see Table 2).

Table 2

CANDIDATES ENTERED FOR 1 OR 2/2+ SCIENCE SUBJECTS BY SCHOOL TYPE

School Type	No. & % Sitting Any Science Subject		No. & % Sitting 2/2+ Science Subjects	
	#	%	#	%
Boys' Single-sex	287	73.8	182	46.8
Girls' Single-sex	211	49.3	134	31.3
Boys' Co-ed.	340	62.0	223	40.7
Girls' Co-ed.	213	41.6	128	25.0

In respect of students passing 2/2+ science subjects, the following pattern was established (see Table 3). Percentages were determined from the total number of students entered for at least one science subject.

Table 3

NUMBER & PERCENTAGE STUDENTS PASSING 2/2+ SCIENCE SUBJECTS BY SCHOOL TYPE

School Type	No. & % Passing 2		3		4		No. & % Passing 2 to 4 Sciences	
	&	%	&	%	&	%	&	%
Boys' Single-sex	47	16.4	27	9.4	7	2.4	81	28.2
Girls' Single-sex	33	15.6	17	8.1	8	3.8	58	27.5
Boys' Co-ed.	50	14.7	39	11.5	7	2.1	96	28.2
Girls' Co-ed.	27	12.7	12	5.6	2	0.9	41	19.3

One notes that, percentage-wise, girls in single-sex schools registered the largest number of 4-subject passes, boys in the co-educational setting, most 3-subject passes, and boys in single-sex schools, most 2-subject passes. In all instances, girls in mixed schools gained the lowest percentage passes. Taken further, in terms of students' passing 2 to 4 sciences, both groups of males and the girls from single-sex schools manifested a similar pattern of performance [ranging from 27.5% to 28.2%], whereas girls in co-educational institutions registered a lower percentage pass rate [19.3%]. The actual distribution of grades gained is illustrated in Table 4 for all science subjects taken.

Table 4

DISTRIBUTION OF GRADES

Grades	Single-Sex Boys		Single-Sex Girls		Co-Educational Boys		Co-Educational Girls	
	&	%	&	%	&	%	&	%
A	12	4.2	12	5.7	27	7.9	4	1.9
B	48	16.7	29	15.7	44	12.9	17	8.0
C	38	13.2	29	13.7	40	11.8	12	5.6
D	50	17.4	27	12.8	83	24.4	36	16.9
E	137	47.7	110	52.1	136	40.0	80	37.6
O	215	74.9	174	82.5	254	74.7	150	70.4
F	104	36.2	52	24.7	119	35.0	94	44.1
X	20	7.0	11	5.2	24	7.1	28	13.2

This table shows that the largest percentage of As were obtained by male subjects in co-educational institutions

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boys from the co-educational schools also gaining the highest percentage of Ds. Girls from single-sex institutions, on the other hand scored most Cs and Es percentage-wise. Most Fs were gained by girls in co-educational schools.

The data were examined, finally, on an individual science subject basis (see Table 5).

Table 5

PASS RATES PER SUBJECT AREA

Subjects	Single-Sex Boys (N=287)		Single-Sex Girls (N=211)		Co-Educational Boys (N=340)		Co-Educational Girls (N=213)	
	f	%	f	%	f	%	f	%
Mathematics	108	37.6	62	29.4	95	27.9	39	18.3
Pure Maths.	3	1.1	0	0.0	14	4.1	8	3.8
Further Maths.	16	5.6	0	0.0	4	1.2	0	0.0
Physics	52	18.1	21	10.0	59	17.4	10	4.7
Chemistry	61	21.3	57	27.0	92	27.1	42	19.7
(Av.% Physical Sciences)		11.5		13.3		15.5		9.3
Zoology	4	1.4	0	0.0	16	4.7	11	5.2
Biology.	51	17.8	47	22.3	30	8.8	26	12.2
Geology	0	0.0	0	0.0	3	0.9	3	1.4
Geography	10	3.5	20	9.5	17	5.0	10	4.7
(Av.% Biological Sciences)		5.9		8.0		4.9		5.9

The salient points to be noted are as follows:

- Girls from both school types gained a larger percentage of passes in the biological sciences than was the case for the boys. This was particularly evident in the case of Biology.
- While boys attending co-educational schools did best in the physical sciences, girls from single-sex institutions perhaps surprisingly edged out their male counterparts. The other group of girls, however, gained a much lower average percentage of passes than did any of the other three groups. Of interest is the fact that girls in single-sex schools did quite well in Chemistry and

Mathematics (excluding Pure and Further Mathematics, where no candidate was entered), but were certainly over-shadowed by both groups of boys for Physics.

DISCUSSION

To some extent findings of this present investigation have mirrored those of the earlier study conducted at grade 11 (Note 2), in that it has established that at Advanced Level (grade 13) girls in the single-sex setting have out-performed their counterparts attending co-educational schools in the sciences. Interestingly, boys entered from co-educational institutions have given a better showing at grade 13 than at grade 11, where their performance level, in terms of science subjects passed, was marginally below that of girls in single-sex schools, and at a markedly lower level than boys attending single-sex institutions.

Nonetheless, a similar conclusion may be drawn from the findings of both studies in respect of girls of either school type: it is apparent that single-sex institutions provide a more favourable environment regarding students' performance in the sciences than do the co-educational schools. Research conducted in the United States (Note 4) suggests that school organisation plays a significant role here. However, in terms of the outcomes of education as measured by academic achievement, Lee and Bryk (Note 5), again writing of the USA, found that:

> "There were no achievement areas (including the sciences) in which coeducational-school students surpassed their single-sex-school counterparts at either sophomore or senior year." (p. 388).

This is certainly in contrast to the Jamaican data which, as reported previously, strongly suggests that the single-sex school provides a more favourable setting (at least, in terms of performance in traditional masculine areas) than the co-educational school. Although dealing specifically with the United Kingdom, Delamont (Note 6) has provided an explanation which is pertinent to the present investigation

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Writing of single-sex schools, Delamont has suggested that:

> "..... girls do not have to defer to boys. The teachers' attention and concern must go to girls: it must be girls who are perceived as the most able students ..... girls are protected from the daily message supplied by boys that girls are unworthy." (pp. 120-121).

Hamilton (Note 2) has also concluded that the effects of sex stereotyping are more sharply apparent in co-educational schools, because here there seems to be a stronger need to differentiate between the sexes:

> "Thus, even if subjects such as Mathematics and the sciences are technically available to girls (in co-educational schools) they are more likely than their single-sex institutional counterparts to get the message that such subjects are un-feminine, and beyond their grasp, intellectually. In addition to peer-influence, teachers in co-educational schools are also likely to display preferential treatment, subtly or otherwise, in favor of boys."
> (p. 545).

Blackstone (Note 7) has gone so far as to point out that, in the co-educational setting, girls experience difficulty in competing for success with boys, moreso than with other girls, for they fear that this may prove threatening to the boys, who, as a consequence, will reject them as potential sexual partners.

One would recommend strongly, therefore, that Jamaican teachers in co-educational schools in particular , guard against displaying any behaviors which might suggest sex discrimination. They need to make a concerted effort to break down the myth that girls should be docile, dependent and passive recipients in the learning situation, at the same time convincing them that they are of equal worth, academically, as the boys. More, therefore, has to be done in respect of motivating girls, through enhancing their self-worth and confidence.

Hamilton's grade 11 research (Note 2) offered a tentative suggestion for girls in co-educational schools to be taught apart from boys in those subjects such as the sciences, which are strongly masculine-typed. This would be totally unrealistic for sixth form (grades 12 and 13) where, each year, there is a relatively low number of students enrolled for GCE Advanced Level courses. Perhaps Jamaica should explore more intensively the possibility of organising small regional Sixth Form Colleges, where "A" Level students from all the schools in a particular area could be enrolled in one institution staffed by those schools' "best" teachers. It would then be numerically economical to consider separating the sexes for subjects such as the sciences.

NOTES

1. *This has been suggested by a number of Jamaican researchers such as M.A. Hamilton and E.A. Leo-Rhynie (1979-1980) in "Sex-role stereotyping and education: The Jamaican perspective": in* Interchange, *10, 46-56.*
2. *See M.A. Hamilton's article "Performance levels in science and other subjects for Jamaican adolescents attending single-sex and co-educational high schools": in* Science Education *(1985), 69 (4), 535-547, which looks at performance at grade 11.*
3. *Applicants to the University of the West Indies are virtually assured of a place if they have two "A" Level passes. They may, however, be considered for admission if their performance at "O" Levels/CXC is of a high quality, but, in most instances, they are required to do an additional year of university.*
4. *The reader is referred to J. Goodlad's (1984) publication* A place called school*. N.Y.: McGraw Hill; and J.S. Coleman's (1961) book* The adolescent society*. N.Y.: Free Press of Glencoe.*
5. *See the article by V.E. Lee and A.S. Bryk (1986) on "The effects of single-sex secondary schools on student achievement and attitudes": in* Journal of Educational Psychology*, 78 (5), 381-395.*

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6. This is the conclusion of S. Delamont (1980) reported in *Sex roles and the school*: London: Methuen.
7. See T. Blackstone's (1976) article on "The education of girls today": in J. Mitchell and A. Oakley (Eds.) *The rights and wrongs of women*: Harmondsworth: Penguin.

GIRLS IN SCIENCE: U.S. AND JAPAN

Eve Humrich

Second IEA Science Study

INTRODUCTION

The International Association for the Evaluation of Educational Achievement (IEA) collected data during the Second International Science Study (SISS) in 1983 and 1984. The United States and Japan both took part, thereby giving us the opportunity to compare national differences as well as gender differences. This survey attempts to give an overview of gender differences in the U.S. and Japanese ninth grade population, a population that many feel to be the pivot upon which all future science education hinges.

REVIEW OF THE LITERATURE

There is much being written today about science education in Japan. Comparisons of U.S. and Japanese science education are becoming common (Fetters et al., 1983; Easley, 1985; Ferguson, 1985; Jacobson et al, 1986; Yoshida, 1986). These works cited are just a partial list, and all of them have been published within the last four years. However, while we ostensibly discuss differences and similarities in science education, what we neglect to point out is that there are also gender differences (and similarities) in science education within the two countries.

A wealth of literature on gender differences is also extant, but this literature pertains mainly to gender differences within a specific country (usually the U.S.). A few papers regarding international gender comparisons have appeared. Some are based on data collected by the IEA (Finn et al., 1979; Finn, 1980), but there are none dealing specifically with U.S.-Japanese comparisons.

SECOND INTERNATIONAL SCIENCE STUDY

SISS tested three populations in 1983 and 1984. Population 1 was fifth grade students, Population 2 was ninth grade students, and Population 3 was twelfth grade students. Data from many of the participating nations are not yet available, but both Japan and the U.S. have completed their studies, and the information is being published.

All three populations are of interest in a comparative study of national and gender differences, but the ninth grade was chosen for this paper because of its importance as a stepping-stone between the generalized course of science study found in early grades, and the specialized course of science study (ie- biology, chemistry, and physics) found in the high schools. In many cases, the ninth grade is the last grade of compulsory science education, and for many students, the last science course that will be taken.

Population: The effective U.S. population was composed of 1930 students: 994 (51.5%) of the students were girls and 936 (48.5%) were boys. The effective Japanese population was 7610 students: 3683 (48.4%) girls and 3927 (51.6%) boys.

Instruments: The general science test given to ninth graders in both the U.S. and Japan consisted of 30 international items on a core test, with four additional rotated tests consisting of 10 international items and five national option items. Each student was given the core test and two of the rotated tests (which had been arranged into six forms), for a total of 60 science achievement items.

In this survey, the national option items were ignored, and a comparison was made solely on the international items that were common to both countries.

The items on each test were categorized as either physics, biology, chemistry, or earth science. Table 2A shows the breakdown by category for each form of the test.

TABLE 2A
CATEGORIES OF TEST ITEMS

FORM	PHYSICS	CHEMISTRY	BIOLOGY	EARTH SCIENCE
1 (A+B)	20*	9	15	6
2 (A+C)	16	10	17	7
3 (A+D)	15	10	17	8
4 (B+C)	18	9	16	7
5 (B+D)	17	9	16	8
6 (C+D)	13	10	18	9

* Number of items in each category on each form of test.

Table 2B lists the average scores achieved on each form of the test. As can be seen, Japanese girls outscored U.S. girls on all forms. It is interesting to note, however, that U.S. girls did the best on Form 1, the form with the most physics items, and did least well on Form 6, the form with the least physics and most biology items.

Japanese boys outscored all other groups. It should be pointed out that, although the average for U.S. boys was higher than for Japanese girls, on certain forms (Forms 1,2, and 4) Japanese girls did about as well as U.S. boys.

TABLE 2B
AVERAGE SCORES FOR EACH FORM OF INSTRUMENT

FORM	U.S. GIRLS	JAPANESE GIRLS	U.S. BOYS	JAPANESE BOYS
1 (A+B)	60.8*	66.1	66.3	70.0
2 (A+C)	59.4	66.3*	65.7	70.3*
3 (A+D)	59.7	64.4	66.6*	69.0
4 (B+C)	59.2	64.8	64.8	69.2
5 (B+D)	59.5	62.9	65.7	67.9
6 (C+D)	58.2	63.1	65.1	68.1
AVERAGES:	59.5	64.6	65.7	69.1

* Denotes form with highest average score for particular population.

NATIONAL DIFFERENCES

In looking at specific items, we find that Japanese girls outscored U.S. girls by at least 10% on 27 items. The categories of these 27 items are as follows: two earth science, four biology, six chemistry, and 15 physics. The four items with the greatest difference (over 30%) dealt with circuit diagrams (33.5%), refraction of light through a magnifying glass (44.3%), reading and interpreting a chart concerning temperature (32.3%), and the advantage of using a lever and fulcrum (40.4%). U.S. girls outscored Japanese girls by at least 10% on 13 items: two earth science, seven biology, two chemistry, and two physics. An item comparing evaporation rates of gasoline and water is the only item with more than a 30% difference favoring U.S. girls (38.9%). Although Japanese girls scored an average of five percent higher than U.S. girls overall, physics was the area with the largest discrepancy.

Japanese boys outscored U.S. boys on 18 items: one earth science, three biology, four chemistry, and 10 physics. There was a greater than 30% difference on three of the same items as favored Japanese girls: the circuit diagram (32.4%), refraction of light (35.9%), and the lever and fulcrum (37.0%). U.S. boys outscored Japanese boys on 15 items: one earth science, nine biology, two chemistry, and three physics. U.S. boys and girls demonstrated a similarity in that the only item in which U.S. boys outscored Japanese boys by better than 30% (31.3%) was the same one found to favor U.S. girls, the item concerning evaporation rates. Once again we see that U.S. students appear to be stronger in biology and weaker in physics than the Japanese.

The items that the Japanese students did appreciably better on than U.S. students were almost the same for both boys and girls. This also held true for the U.S. students, with both girls and boys outscoring their Japanese counterparts on the same item.

Reviewing the test items by objectives (ie-knowledge, comprehension, and application), we find that the U.S. scores were evenly distributed while the Japanese seemed to score higher in areas of comprehension and application (Table 2C).

TABLE 2C
PER CENT CORRECT BY OBJECTIVES

	KNOWLEDGE	COMPREHENSION	APPLICATION
U.S. Girls	58.8%	59.0%	60.0%
Japanese Girls	57.8%	66.8%	67.2%
Difference	1.0%	-7.8%*	-7.2%
U.S. Boys	65.7%	64.6%	65.6%
Japanese Boys	63.7%	70.5%	70.8%
Difference	2.0%	-5.9%	-5.2%

* Negative number (-) favors Japanese students

In comparing the gender differences in both countries, a general pattern was detected. Items having significant gender differences in Japan tended to demonstrate significant gender differences in the U.S.

There were nine items on which Japanese boys outscored Japanese girls by ≥10%. Two of these were earth science, two were biology, and five were physics. There were 17 items on which U.S. boys outscored U.S. girls by ≥10%: two earth science, five biology, eight physics, and two chemistry (Table 2D).

TABLE 2D
ITEMS WITH GREATEST DIFFERENCE FAVORING BOYS (≥10%)

	PHYSICS	CHEMISTRY	BIOLOGY	EARTH SCIENCE
U.S. (N=23)	8 (14.4%)*	5 (12.9%)	5 (12.1%)	5 (15.3%)
Japan (N=9)	5 (13.2%)	- N/A	2 (13.4%)	2 (17.1%)

*Average percent gender difference favoring boys for each category.

Six of the items favoring boys were the same in both countries. The earth science item pertained to reflected light enabling us to see the Moon. One biology item diagrammed a laboratory set-up used to measure the rate of respiration of an insect. Students were asked what could be measured with the apparatus shown. A second biology item asked the main way sweating helps your body. A physics item showed three weights (in newtons) suspended in series on a thread. Students were required to know the tension on the thread between two of the weights. Another physics item asked why crews of two ships in space could not communicate with each other by shouting. The third physics item told students that a uniform rod with a pivot at its center was acted on by two forces. Students were given a choice of five diagrams to describe forces which would cause a turning effect.

There were no items for either the U.S. or Japanese populations on which girls did significantly better than boys. There were seven items girls of both nations had in common, however, on which they scored highest relative to their male counterparts: four of these were biology, two physics, and one earth science.

The biology items covered the following: (1)why refrigerated milk does not go sour for a long time; (2)planning an experiment to discover whether a certain seed germinated best in the dark or light; (3)the main reason restaurants do not serve reheated meat; (4)which organ is not in the abdomen. In physics, students were asked why it becomes increasingly more difficult to put air in a bicycle tire using a hand pump; and, given a diagram of a stoppered bottle with water, why no more water would go into the bottle. The one earth science item required students to read a thermometer and interpret a chart of temperatures.

Items were broken down by content (ie- physics, biology, chemistry, and earth science) to observe the validity of the hypothesis that girls do better in biological sciences while boys do better in physical sciences (Table 2E).

TABLE 2E
AVERAGE PERCENT CORRECT BY SUBJECT

	PHYSICS	CHEMISTRY	BIOLOGY	EARTH SCIENCE
U.S. Girls	58.6%	51.2%	63.3%	64.8%
U.S. Boys	66.5%	55.2%	67.8%	72.6%
Difference:	7.9%	4.0%	4.5%	7.8%
Japanese Girls	71.3%	54.5%	63.3%	66.8%
Japanese Boys	76.3%	58.5%	65.8%	74.2%
Difference:	5.0%	4.0%	2.5%	7.4%
Number of items in each category	(N=23)	(N=15)	(N=23)	(N=9)

As can be seen, this hypothesis appears to hold true for the U.S. The greatest gender differences are in physics and earth science, while chemistry and biology items exhibit smaller gender differences. This might be explained by Kelly's hypothesis (Kelly, 1978) of "in school" and "out-of-school" sciences. She feels that both biology and chemistry are primarily learned in the classroom, hence both boys and girls have an equal opportunity to become familiar with the subjects. Physical sciences, however, may be learned outside the classroom (such as fixing a bicycle or helping rewire an appliance at home). Girls may not have as much experience with these tasks as do boys.

If we look at Japan, we can see that, although most of the gender differences parallel those of the U.S., the difference in physics is somewhat smaller. Also of note, Japan outscored the U.S. in all areas except biology.

DISCUSSION

Japanese students scored higher on physics items than did U.S. students. This difference is particularly notable because Japanese girls have scored higher than U.S. boys. It has been hypothesized that this achievement in physics is due to the intense concentration placed on mathematics both in school and in *jukus* (cram schools). While math is an important foundation to science in general, it is especially pertinent to physics. The differences between Japanese and U.S. students in the other areas of science are small. In biology, in fact, U.S. students did as well as or better than their Japanese counterparts.

A more puzzling phenomena is the difference seen in the way students achieved in three of the objectives described by Bloom (1976). While girls and boys in the U.S. scored equally well in all three areas measured (knowledge, comprehension, application), Japanese students scored an average of 5-7% higher in comprehension and application.

In the North Carolina-Hiroshima study of lower secondary school students (Mattheis et al., 1985), it was found that approximately 70% of the Japanese sample population had reached transitional or formal levels of thinking (Yoshida, 1986). In the U.S., however, only 31% had reached these levels and 69% were still functioning at the concrete level (Mattheis et al., 1985). Yoshida feels that it is the elementary school curriculum of Japan that prepares students with the reasoning skills necessary for later life. This apparent focus on reasoning skills early in their school career may also help explain the discrepancy between Japanese and American students in overall performance.

We can see that gender differences exist in both countries. In the U.S., the mean difference is 6.2%, while in Japan it is 4.5%. It would appear at first that an obvious explanation for this difference in magnitude is the differential scoring on the physics items. It may be of some surprise to see, however, that U.S. boys also outscore U.S. girls by 4.5% on biology items, while in Japan the sex difference in biology is only 2.5% The reason for this is twofold: Japanese girls do well in physics and Japanese boys do poorly in biology, as compared to U.S. students. The stress placed on math "cramming" and the lower priority given to biology once students leave elementary school in Japan may help to explain this discrepancy.

Keeves (1973) has pointed out that sex differences in science achievement exist in most countries, but magnitude varies. As we can see by comparing differences in the U.S. and Japan, it is not only the magnitude that varies, but also the achievement level in content areas. Further cross-national research is being performed, using additional IEA data as it becomes available. If the pattern holds true we may find more nations where girls achieve in areas other than biology (as we have come to expect in the U.S.). This discovery would lend support to the hypothesis that sex differences are culturally based, and that genetic or hormonal explanations for differences in science achievement have little bearing.

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GIRLS' CONCEPT OF AND ATTITUDE TOWARDS TECHNOLOGY.
THE INTERNATIONAL PATT-RESEARCH

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SUMMARY

All over the world we see an increasing demand of skilled jobs on the labourmarkets. Despite this situation, relatively few girls opt for a technical training or profession.

One of the possible reasons for this is the fact that girls, compared to byos, have a poorer concept of technology and technical professions. Girls also have a less positive attitude towards technology than boys have.

These concepts of and attitudes towards technology are being investigated in the international PATT-research. Participating countries are: Australia, Belgium, Canada, England, France, Hungary, India, Ireland, Italy, Kenya, Nigeria, Poland, Spain, Sweden, the UK, the USA, and the Netherlands. PATT means Pupils' Attitude Towards Technology.

The attitude research started in the Netherlands in 1984, being one of the research-lines in the project Physics and Technology. An attitude-questionnaire was developed with a good validity and reliability. By means of pilot-studies this questionnaire was tested in 11 countries for its possible international properties. The results of these pilot-studies have been discussed at the first PATT-workshop, we organized from 6-11 March in Eindhoven. There was a consensus about 7 attitude-scales and 5 concept-scales. Besides we decided to have 13/14-year-old pupils writing essays about technology. The scales were again tested in the Netherlands on validity and reliability.

At the moment we use the following instruments:

a. an attitude questionnaire containing 60 items,

b. a concept questionnaire containing 28 items,

c. essays for additional information on the concept of technology.

In several countries research has been carried out in the autumn of 1986 using these instruments. We have collected the results, using the PATT-Newsletter as a means of communication.

During the GASAT-4 conference we present the results of research and international comparisons will be made as well. We shall give a report of the second PATT-workshop, to be held in April 1987.

1 INTRODUCTION TO THE PATT-PROJECT

All over the world we see an increasing demand of skilled technical jobs on the labormarkets. Despite this situation, relatively few girls opt for a technical training or profession. One of the possible reasons is the fact that, compared with boys, girls have a poorer concept of technology and technical professions. Girls also have a less positive attitude towards technology than boys have.

These concepts of and attitudes towards technology are being investigated in the international PATT-research.

PATT means Pupils' Attitude Towards Technology. It is the name of an international research project which was started in 1985 on the initiative of our group at the Eindhoven University of Technology. It is the aim of the project to contribute to the development of the subject 'Technology' in secondary general education.

We do this by means of 'school-near research focused on pupils'. Specially for this purpose we have developed instruments to measure the concept of and the attitude towards technology of 13/15-year-old pupils. The results of this research gives us information that can be used for a technology curriculum that is adjusted to the pupils' living environment and also to the way they experience things. This is important because large groups of pupils, and **these are mainly girls**, traditionally do not have a technical orientation.

At the moment researchers from 15 countries are participating in the investigation. The participants may be interested for various reasons: in some countries there already is a subject 'technology' in general education, and the investigators from these countries are interested in the evaluation and improvement of the curriculum (the so-called assessment-research, as is the case in, for example, Hungary, Poland and Sweden). For other countries, where the subject 'technology' has not yet been introduced, the PATT-research gives an important contribution to the development of the new curriculum (as is the case in the Netherlands, the United Kingdom and Belgium).

It was the first task of the PATT-researchers to develop instruments that could be used internationally. The developing of these instruments is described in section 2. In section 3 we report the results of two researches: one in the Netherlands and one in France. At the GASAT-4 conference we shall present the results of some more countries. In section 4 we discuss the results of the PATT-research.

2 THE DEVELOPING OF INTERNATIONAL INSTRUMENTS

2.1 Which instruments have been developed?

At international conferences (a.o. GASAT-3 in London, UK, 1985 and ICSU-UNESCO in Bangalore, India, 1985) contacts were made to test the questionnaire that had been developed in the project Physics and Technology (1) in other countries. The interest from abroad in this research was great. In 10 countries a pilot study has been carried out among 200 pupils in their native language. With this the PATT-research actually started.

During the first PATT-workshop in Eindhoven, in March 1986, with participants from Australia, Canada, France, Hungary, Kenya, Nigeria, Poland, Sweden and the United Kingdom, the results of the pilot studies have been discussed. It was the aim of this conference to find out whether it was possible to develop **one** instrument. The findings of the researchers were favourable (2).
However, to express sufficiently the cultural differences between the countries a separate instrument, beside the **attitude** instrument, has been developed to measure the **concept** of technology. This instrument also consists of questions/items. The character of these questions is different from that of the attitude questions. The difference between attitude questions and concept questions is mainly a distinction between affective and cognitive questions. Cognitive questions mostly are either true or false and do not necessarily affect the attitude. Someone with a wrong concept of technology may very well have a positive attitude.
Moreover, there was a proposal to have pupils writing supplementary essays on technology which give additional information on the concept of technology that was used by the pupils. In case we would only use the concept-questionnaire, the one with the so-called closed questions, this would give too little opportunity to find out enough about the conception that pupils - spread internationally over so many different backgrounds and cultures - have of the, for different countries, rather different concept 'technology'.

So now we are using **three instruments** in the PATT-research:

1. **an attitude questionnaire** consisting of 60 statements/items, belonging to **6 scales;**
2. **a concept questionnaire** containing 28 statements/items, belonging to 5 **characteristics** of technology;
3. (short) **essays** to obtain additinal information.

We will talk in greater detail about these instruments now. How did these instruments come about from a methodological point of view (3)?

2.2 Methodological aspects of instrument development (3)

2.2.1 Attitude instrument

The attitude questionnaire as it can be used consists of 6 scales of 10 items each. These scales correspond with the various dimensions of which the attitude towards technology of 13-year-old pupils consists. The **identification** of the scales took place on the basis of the **empirical** results of the various countries. The technique we used was **factor analysis.** This technique enables us to see underlying dimensions in the attitude.
The **selection** of the items was made on the basis of an investigation into the quality of the items and their relevance to a scale, using descriptive statistics and reliability analyses.

Finally we added items until each group consisted of 10 items, in which the description of the scale was used as a criterion. This is called **face validity.**
As an example we would like to mention scale 1, which we named 'interest/leisure'. As a scale description we arrived at: 'the extent to which pupils engage in or would like to engage in technical activities outside school'. On the basis of this we can construct items such as:

1. I like to read technological magazines.
2. If there was a hobby club about technology I would certainly join it.

2.2.2 Concept instrument

This instrument consists of 28 items. These concept items are based on the five characteristics of 'technology' we use in the project Physics and Technology.
The five characteristics of technology are:

1. technology is a specifically human acitivity,
2. technology influences all aspects of society,
3. technology and science are interrelated,

4. designing, (creativity) and technical skills play a major part in technology,
5. the three dimensions or 'pillars' of technology are: matter, energy and information (4).

Making these 5 characteristics operational by means of items in a 'true-false' format entails a number of problems. The biggest problem may well be the large theoretical distance between the abstract and sophisticated characteristics of technology and the environment and the way of thinking of 13/14-year-olds.

We tried to reduce the level of abstraction of the 5 characteristics, while at the same time maintaining a fair face validity. For each of the 5 characteristics we thought up items.

As an example: the first two features of technology can be described as follows: technology is directed and controlled by man and intervenes all aspects of society. Typical items for these features are:

1. Only technicians are in charge of technology. yes/no
2. Technology is as old as mankind. yes/no
3. Technology is meant to make our life more comfortable. yes/no

2.2.3 Essays

At the first PATT-workshop (1986) it was decided to have 13/14-year-old pupils writing 'supplementary essays'. The aim of this is:

- to get additional information about the concept pupils in several countries have of technology, and/or
- as a means of determining the validity of the attitude questionnaire.

We suggested the following title for the essays:

'Technology can mean different things to different people. When you read the word 'technology', what comes into your mind? What does technology involve?'

Please give a short description.

The method we used to analyse the essays is derived from a method which was used in the analysis of Dutch essays.

What the processing boils down to is in short the making of an inventory and subsequently the scoring of elements or opinions that occur in the answers. The model is simple, objective, and the loss of information is relatively small.

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The product of the categorization is a data-matrix. The qualitative data are more or less quantified in a data-matrix. The matrix yields variables which have been measured at a low scale-level (nominal; the variables can only be divided according to two features, viz. being mentioned in an essay or not being mentioned).
The main purpose of an essay analysis may already be attained by means of a frequency analysis. The matrix gives ordened information about the concept of technology that was used.
The results may be looked at for each (classified) group or group of pupils (boy-girl, type of school).

What results can be obtained by analyzing the essays?
From the Dutch analysis it became evident, among other things, that technology is associated with **products** and not with **processes** (designing, inventing, creativity are not regarded as part of technology, this as opposed to computers, domestic equipment, aeroplanes, space crafts, robots, etcetera).

2.3 Use of the instruments

The investigators of the various countries are all using the instruments in their own way. In most cases the context of the research is the position, the contents, the teaching and learning of the subject 'technology' as it is offered or going to be offered to the whole age-group of 12 to 15 years.
The context may also be the position/context of only technical education.
Some investigators will look more specifically for significant differences between subgroups:

- **girls and boys,**
- pupils from urban versus rural areas,
- influence of inservice training or no inservice training,
- influence of the profession of the parents (technical or not).

The participants in each country can make their own choice for an investigation among 300 pupils approximately. In case it is required by the investigation, items may be added to the questionnaires.

The participants were asked to send the results, in analyzed or semi-analyzed form (depending on the researchers' possibilities) to Eindhoven. Here the results are collected and international comparisons can be prepared.

All the news/results/changes etcetera are passed on in special PATT-Newsletters. These newsletters are an important means of communication and coordination for the continuation of the PATT-research.
The results of the research with the new instruments are discussed at the next PATT-workshop in 1987. This conference, PATT-2, shall be held in Eindhoven from April 9-14, 1987.
The major aim of this second workshop is: the consequences of these studies for the separate subject 'technology'.

We shall now discuss the results of two case studies with the afore-mentioned instruments, one in the Netherlands and one in France.
At GASAT-4 we shall present an overall view of the research, because at that time more data will be available.

3. RESEARCH WITH THE PATT-INSTRUMENTS

3.1 Case study in the Netherlands

In correspondence with the research into the concept of and the attitude towards technology of pupils of the second year secondary general education we carried out a nation-wide investigation with the 3 PATT-instruments in junior vocational education (5), which is the other option that pupils can choose after they leave primary school.
The variables of which we expected that they would have an impact on the attitude towards and the concept of technology, were:

1. the type of school chosen by the pupil:	- technical or non-technical
	- categorial or non-categorial
2. gender:	- boy or girl
3. profession of parents:	- technical or non-technical
4. urbanization:	- rural or urban.

We furthermore investigated whether there is a positive relation between the concept of technology and the attitude towards technology. We investigated the variables by comparing the mean raw scores on the various scales. The results were as follows:

1. It appeared that the parents' profession and the degree of urbanization have no influence on the attitude towards technology and the concept of technology. Attending a categorial or multilateral school does not have any influence either.
2. There are significant differences in the way boys and girls score on the attitude- and concept-scales (see table 1). The attitude of boys is more positive and their concept of technology is better.

Table 1. Boys' and girls' scores in the Netherlands.

Scales	Mean score boys (n = 1365)	Mean score girls (n = 982)	T-value	Prob.
Interest scale	2.35 *(1)	3.00	-26.75	0.000
Sex scale	2.48	2.16	11.57	0.000
Difficulty scale	2.30	2.19	5.18	0.000
Consequences scale	2.25	2.60	-16.84	0.000
Techn. and Society	.50 *(2)	.36	17.38	0.000
Techn. and Sciences	.48	.33	14.44	0.000
Techn. and Pract. Skills	.72	.65	7.53	0.000
Techn. and Pillars	.57	.45	12.26	0.000

*(1) the lower the score, the more positive the attitude.

*(2) the nearer the score to 1, the better the concept.

3. Finally we found a **significant correlation between the score on the concept-scales and the score on the attitude-scales** (R = .41; P = 0.000), which means that a better concept of technology may result in a more positive attitude towards technology. It appears that the feature 'Technology and society' correlates most strongly with the attitude.

3.2 Case study in France

In France the research consisted of a limited sample (n = 170), but the researchers did test a large number of variables for their possible influence on the attitude towards technology and the concept of technology.

These variables were:

- gender,
- parents' profession,
- parents' level of training,
- toys used in childhood (technical or non-technical),
- furthermore a number of psychological variables, such as inclination to emancipation, resoluteness, self-confidence, self-concept.

Also from this case study it appears that **'gender' is the most important factor to explain the attitude towards technology and the concept of technology.** Again it is evident that boys have a more positive attitude towards technology and a better concept of technology than girls (see table 2).

Tabel 2. Boys' and girls' scores in France.

Scales	Mean score boys (n = 77)	Mean score girls (n = 92)	T-value	Prob.
Interest scale	2.31	2.73	-4.82	0.000
Sex scale	2.39	1.87	5.11	0.000
Difficulty scale	2.77	2.62	-2.24	0.030
Consequences scale	2.46	2.65	1.74	0.085
Curriculum scale	2.71	3.00	-2.91	0.004
Career scale	2.67	3.09	-3.96	0.000
Techn. and society	.52	.44	2.58	0.011
Techn. and sciences	.42	.36	1.60	0.116
Techn. and Pract. Skills	.58	.59	-0.34	0.737
Techn. and Pillars	.63	.50	3.23	0.002

As in the Dutch case study, here too there is evidence for a positive relation between concept and attitude (R = .35; P = 0.000).

4. DISCUSSION

The central question of the PATT-research is: 'What do pupils think of technology?'.

In the investigation that was carried out to find an answer to that question it appeared that we have to make a distinction between 'what is their attitude towards technology?' and 'what concept do they have of technology?'. The research gives an answer to these questions.

It appears that we can distinguish various dimensions in the attitude towards technology, such as interest in technology and the consequences of technology. Also the concept that pupils have of technology can be split up into various aspects, such as the relation between technology and society, and the relation between technology and (natural) sciences.

It is evident from the research, that there is a correlation between the attitude towards technology and the concept of technology.

A vague concept of technology often goes with a less positive attitude towards technology, a clear concept of technology, on the other hand, is likely to go with a more positive attitude towards technology. This makes it rather obvious to presume, that a better conceptualization of technology will contribute to a more favourable attitude towards technology.

The results of the research show, that in general girls have a less positive attitude towards technology.

Therefore it is important, particularly in the teaching of technology, to see to it that girls get a clearer concept concept of technology. Particularly a better concept of the feature 'technology and society' may contribute to girls adopting a more positive attitude towards technology.

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Females and Physical Science: Is Tinkering an Issue?

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Abstract

One of the factors affecting students' success in science is their existing knowledge prior to instruction. One theoretical position which can be taken is that such knowledge is constructed through prior experience. This study focused on one type of prior experience, namely tinkering. It examined the role of tinkering in students' approaches to the study of electricity.

The appearance of tinkering in the science education literature centers around the gender issue of females and science. Specifically research has focused on specific topics within physics such as electricity, where the claim has been made that the greatest gender difference occurs. However, before one can investigate such a claim tinkering needs to be defined within the context of physical science.

This study utilized a case study approach which consisted of multiple cases designed to explore tinkering and how it interacts with instruction in one area of physical science, with a focus on how gender gets played out in this context.

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Introduction

There is evidence in science education literature (Driver & Easley, 1978, Novak, 1977; Osborne & Gilbert, 1980, and others) which suggests that the role of students' existing knowledge in learning science is a central issue specifically. Driver (1981) argues

> Far from being "tabula rasa" of repute, pupils bring to their school learning in science ideas, expectations and beliefs concerning natural phenomena which they have developed to make sense of their own past experiences. These alternate frameworks, in some cases strongly held and resistent to change, in others flexible and with many internal inconsistencies, have their influence on the effectiveness of formal school science programmes (p. 93)

Students' prior knowledge includes not only the cognitive dimension of childrens' science but also the affective and psychomotor dimensions. These three dimensions are all active components in what this study refers to as tinkering.

Tinkering is one type of prior experience which some students bring to science instruction. The question is what does it mean if some students have had certain experiences such as tinkering and others have not? Reference to tinkering in the science education literature centers around the gender issue of females and science. It is within that context that the role of tinkering as a prior experience has become an issue. In fact, one conjecture that has been advanced to explain female underachievement on such measures as International Association for the Evaluation of Educational Achievement (IEA) 1970's, National Assessment of Educational Progress (NAEP) 1970, 1977, 1978, Assessment Performance Unit (APU) 1979 and B.C. Science Assessment 1978, is that females lack prior tinkering experiences in the physical sciences (Erickson & Erickson, 1984, Johnson & Murphy, 1984, Kelly, 1981, Lie & Bryhni, 1983, and Walberg, 1967). Specifically, such arguments have focused on specific topics within physics such as electricity,where the claim has been made that the greatest gender difference occurs. Clearly, before one can investigate such a claim then tinkering needs to be defined within the context of how it interacts with science instruction.

Towards a Definition of Tinkering

As a result of a review of science education literature and the preliminary investigations of this study, a tentative definition of tinkering was constructed to provide some conceptual boundaries for the study. A 'actional' approach was taken in defining tinkering. That is, a tentative definition was constructed prior to the study but this definition was not regarded as fixed as in the 'classical' approach. Tinkering was defined from a physical science perspective as:

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Preliminary Results

The data analysis is currently in progress, but some preliminary findings have emerged The following should be viewed as hypotheses generated from the study

1. Tinkering is a process by which we intuitively make sense of the world at a commonsense level It has concrete to abstract dimensions and exists at various knowledge levels from universal to unique
2. The type of tinkering that is referred to in science education literature is only one type of tinkering
3. While males tinker more at the concrete level with physical science type apparati than females they also tinker at the abstract level Females however tinker more at the abstract level of physical science than they do at the concrete level
4. There appears to be a typology of tinkering within physical science - utilitarian technological and scientific Males tend to place in all three categories whereas females are more likely to be scientific than technological or utilitarian
5. There is both depth and intensity to tinkering Depth ranges from novice to master and intensity ranges from obstinative to compulsive
6. Preliminary evidence suggests a reasonably strong interaction between tinkering and instruction, with the obstinative and the compulsive tinkerers being the most disadvantaged
7. In terms of tinkering with electricity females tend to be novices wheras males tend to range from novice to master

A process of acquiring commonsense knowledge which is a practical or hands-on activity that involves prior experience with manipulating physical objects such as mechanical and electrical devices. It consists of interactive, affective, psychomotor and cognitive dimensions, with those dimensions consisting of low to high stages, with the transition from the sphere of commonsense knowledge to the sphere of scientific knowledge occurring when the cognitive dimension reaches its higher stages.

Methodology

The methods employed in this study were of a qualitative nature. The specific form of the study was multiple case studies.

The study consisted of three phases. The first phase was a very thorough process of preliminary research which involved in-depth interviews with subjects known to be tinkerers, and classroom observation of tinkerers engaged in the study of electricity. This phase provided some direction as to what might be involved in tinkering, which led to a definition of tinkering and to the identification of some criteria for the selection of tinkerers.

The second phase or pilot study involved classroom observation of tinkering and the piloting of electrical tasks to be used in later interviews with target subjects.

The actual study or third research phase consisted of three stages. A review of these three stages is now necessary.

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Stage One. Selection of Target Students

After observing a number of grade nine classes for six weeks one class was selected. This class consisted of 27 students from which nine target subjects (five males, four females) were selected for close observation. Subjects were selected who had varying experiences with tinkering. The following criteria were used as a basis for the selection:

1. information provided on potential subjects by former grade seven and eight science teachers,
2. a survey of students' prior experiences with electricity which directly related to the unit being taught, and
3. classroom observation of potential subjects for a six week period.

Stage Two. Interviews

Clinical interviews were conducted with each target subject. The interviews involved the completion of six electrical tasks (three in-school type tasks and three out-of-school type tasks). While students were doing the tasks they were engaged in a reflective conversation (Schön, 1983) focusing on prior experiences with electricity and what they were doing in completing the tasks. The interviews were videotaped.

Stage Three. Classroom Observation of Target Subjects

The methods employed in the classroom observation of target subjects were of an anthropological or ethnographic tradition. The emphasis was placed on describing tinkering in terms of the total context. This included long hand field notes, audio tapes, and xerox copies of student's work.

Discussion

On the surface, one might suggest that a lack of tinkering with mechanical and electrical devices explains why females avoid physical science and why there are noticeable differences in the performance of males and females on such topics as electricity. The problem however is much more deeply rooted than that. It has more to do with the role of students' existing knowledge in science instruction. If tinkering can be viewed as producing prior knowledge then this study suggests that tinkering can either interfere with the teaching process or enhance it.

Based on the conceptualization of tinkering which has evolved in this study it is important to note that while females tinker less at the concrete level they do tinker at the abstract level. This clearly has implications for physical science instruction.

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WOMEN'S ACCESS TO SCIENTIFIC AND TECHNOLOGICAL ACTIVITIES IN MALI

Mrs. Mariko Fadima Siby

SUMMARY

1) The participation of women in scientific and technolgical activities in Mali has come up against customs and traditions. This in precolonial malian society was patriarchal, and the man had all the power. The woman was secondary and did only household work. Boys' education was different from that of girls in whom a feeling of inferiocty was developed. The woman has to obey man and submit to him.

The french colonial conquest came with the institutional schooling primarily for boys as parents did not see the necessity of sending their daughters to school. With time however a few yound girls from rich families attended the first years of school. In a few rare cases they would learn minor crafts without in any case questionning the traditional male-female relationships.

It was only after the country became independent with the ensuring institution of the right to education for all that a relatively important number of young girls have been able to study further and assure an appreciable share in scientific and technological activities. Theirs will be a lasting example, supported by the efforts made by the publics powers.

2) Thus day men and women have a legal equality of opportunities of access to scientific and technological activities however with more and more young graduates being, unemployed, it must be feared that women might turn away from these activities for the benefit of more easily accessible fields.

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Mali is a land-locked country in the heart of West Africa with no opening to the sea. It's a secular country but with a heavy moslem population. A former French colony, it has become independent since 1960. It comprises many ethnic groups living together in perfect harmony.

At the crossroads of African civilizations, it is also one of the summits of tradition knowledge of this socio-cultural content is necessary in order to explain the obstacles which obstruct the access of women and girls to science and technology.

In Mali as well as in most African countries, the woman has been considered since the beginning of the times as a secondary being practically like a slave and even today the after effects of this situation persist particularly in traditional spheres.

In such a context, the father is the supreme commander in the family and decides on the futures of every member. The mother as a result of a lack of economic independence spends her entire life in a state of absolute resignation.

The mothers of yesterday were the ideal women comparable with the one that Ousmane S[illegible] a Senegalese novelist depicted in his novel titled "Les bouts de bois de Dieu."

> "Assitan was a perfect wife according to ancient African tradition : docile, submissive, hard working her only concern, and not as a woman, was to accept and be silent."

Also, girls have been educated in [illegible] that they are not mentally [illegible] with it all their life. That is why docile and obedient [illegible] than boys. [illegible]

All this ideology was shaped by the family head and was well-maintained by him and by the mother who had also grown up in identical conditions.

Children conditionned in this manner since their young age grew up in these prejudices that on entire society shared continued to the great loss of women who were placed on lower social scale. The school and religion were at the beginning, going to contribute to the maintenance and reinforcement of this mentality which institutionalizes the whole power of man. And the fittest will always survive.

From then on the young girl from this system will be convinced of her natural difference from the young boy. The mother will do her utmost to raise her daughter within the strict respect of the established order made of submissiveness and resignation for the woman. Nothing will be spared to keep the father(the man) at the number one position.

Even the advent of the first menstrual period will be interpreted to the young girl by her mother as a sign of her servitude. That means is a way of saying that she is prepared since her early childhood, to a subordinate life.

As she is convinced since her chilhood of her inferiority to the young boy, and as she is made to feel guilty by her education, all that left to the girl is to play the game. She will therefore always seek a secondary position as society wants it. Her essential role will be that of bearing children. Besides, when it is time for her to marry she will be chosen a husband preferably a man capable of paying a lot of money to get her. As she was born and grew in a condition of dependence, she ends up considering him in the same way as men do.

In a parallel direction, no effort is spared to mould the mind of the small boy considered as the family hair, the holder of the family power. The whole family participates in the endeavor, particulary the father. Such a girl confined to domestic chores had no opportunity to learn a craft.

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To summarize, the spirit which prevailed in our society was that the man was the stronger, that he deserved all possible trainings while the woman was to remain the household keeper or to practice a trade that fit that role. White arrival of the white colonists in the XIXe century began, as in all the countries of West Africa the schooling era. Unfortunately with the latter persists the mentality inherited from tradition.

First of all the boys started going to school and later so did a few rare girls from well-to-do parents. Here again the two trainings were separed. The girls were grouped in schools called "girls'schools" which generally had three classes and enrolment took place every two years. The boys' school had six, classes and enrolment was annually. the teaching corps for girls schools was exclusively feminine it continued to make the girl believe in her inferior condition and directed her toward so called feminine professions, generally vocational trainings. Thus the first educated women in Mali were teachers, nurses, midwives, dressmakers etc.....

In short this education has contributed to reinforcing traditional conceptions on the role of the woman and to dissuade girls from-obtaining the necessary knowledge and qualifications in order to play a first order role public life.

The advent of girls' education has been revolution. I must be acknowledge that at the beginning many parents agreed to send their children to school on the condition that they would not stay there for a long time.

For the girls themselves the primary preoccupation would be a good marriage and many children, with the assuption that instruction is only for the improvement of, their role as spouses and mothers. Prior to independence, girls could not attend a technical high school which was exclusively for boys.

The only high school for girls did not allow for the preparation of the high school baccalaureate diplome. The length of training was limited to the end of secondary school, diploma and from there girls graduated generally as teachers or attended short term vocational training institutions. And in most cases parents(generally as the father has decided) managed to give the girl to a fiance before she completed her training and the latter would help the girl father decide upon her future. Two against one(the mother, often an illiterate personne, did not have to put in a word of her own), they ended up winning. Every effort must be made so that her level of education would not be higher than that of her fiance. She ended up quitting school and marrying.

In rare cases where girls had access to the baccalaureate after the girls' school they were sent on an exceptional basis to the boys' high school because of the social status of their parents.

The school system in Mali underwent total upheavel after independence. In 1962 an educational reform took place. A new educational system was born and strived to find solutions to educational problems. The right to schooling was proclaimed without any discrimination based on sex and so was that right to vocational training. The first girls' high school was founded.

The overall level of instruction improved for boys as well as girls. Mixed school were created from primary school to higher education.

This educational reform which vocated the equality of the sexes within the instructional field, has not reached the intended objective in spite of Malian government efforts.

In spite of the mixing girls remained captive to the social environment for a long time and kept being prepared particularly for the litterary branches.

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For example in the girls high school that I was attending, there was two litterary class against one biological sciences class and one math and physics class with only seven pupils.
Almost all those girls who had chosen the science disciplines had decided in favor of medicine, pharmacy, teaching, the economic,sciences, and in a few rare cases, engineering.

Only boys were attending, the technical high school because girls did agree to an orientation toward this school that they found too difficult for them.

The malian government was ahead of mentalities. Thus mentalities had to be changed first because although the laws had changed for the benefit of girls unfortunately the mentalities were not ready for this change intended result.

Later however, the positions of responsibility occupied by the first women who engaged in scientific and technological activities, the material benebit which resulted from them particularly as far as salaries are concerned, including a certain independence from their husbands have many girls and women to understand the world in which they live and to think about their future.

The girls have been engaging since in domains which had so far been reserved exclusively for men. Presently in Mali women are found in all training branches :mathematics, physics, chemistry, the biological sciences, electro-mechanics, auto-mechanics, nuclear physics, refrigeration, hydraulics,etc.......

There are now no more domains reserved for men that women come into contract with in all the branches of economic activities. The girls have gotten rid of the prejudices and are studying in scientific and technical domains which are not supposed to erect any obstacles to them.

However, it must be pointed out that in Mali the school attendence rate for girls remains very low in some ethnic groups the practice continues to marry girls very early, which is an obstacle to their education.

The number of women and girls who have gone into scientific and technological fields traditionally reserved for men has considerably incressed. Political movements have helped the Malian women become aware of her worth and her identity.

In spite of prejudices, which are progressively losing ground as the sciences make progress, Malian women are now taking all risks even if the price they pay is often very high.

Unfortunately Mali is confronted with a new phenomenon which could seriously jeopardize the education of women ; that phenomenon is the problem of unemployment. The tittle developed job markets is satureted and the public employment system has seriously reduced its intake capacity.

Many girls prefer to engage in manual labour sewing, hairdressing,etc... in order to set up their own business some mothers contend that it is useless to study in order to be unemployed later some even totally give up studying in order to marry. The idea of the husband protecting hand is born again.

If adequate care is not taken in time, girls run the risk of losing the few crumbs that they have been able to pick up from the passing feast this time not because of social pressure but by obligation.

Institutionally in Mali no barrier exists to the participation of women and girls in scientific and technological activities. Nor could any delay on lack of balance in this field be attributed to the will or the individual capacities of women themselves.

What do children think? A view of science and scientists

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Abstract

The UK response to the introduction of science and technology into the Primary school curriculum. Signs of changing attitudes to the study of these areas are becoming apparent in the state Primary schools.

The response of young children to scientific experiences and their discussion of science and scientists. Recent research in Tyneside, NE England.

Some thoughts about the future of science and technology education in UK Primary schools (5-11 years).

* * * * *

Current Trends in the UK

Papers at previous GASAT Conferences have argued for the inclusion of science and Technology in the curriculum for all pupils in UK Primary schools. The situation as it exists was discussed and some possible strategies to counteract sexist teaching programmes have been reviewed.[1] Much of the debate in previous conferences has been either with reference to Secondary Education or from a Higher Education perspective. What the authors are concerned about is the possibility that such approaches, worthwhile as these are, can do little to alter entrenched attitudes brought to their studies by older girls and young women undergoing an education including science and/or technology. Few studies have sought to ascertain what young children think and how their perceptions are reflected by how they take part in scientific-technological activities in the classroom situation.

There is much to be optimistic about since the previous papers from the 1983 and 1985 conferences. The uptake of science in the Primary sector is certainly on the increase, but there is still the problem of its sporadic nature and uneven distribution over the country. There are few signs that the subject is in decline in the elementary schools as some American authors have intimated is happening in the USA.

The strong influence of Her Majesty's Inspectorate for Education may at last have started to permeate through to classroom practice and the considerable input of science in the training programme of aspiring teachers may now be bearing fruit. The Department of Education and Science insistence that the structure of revised Bachelor of Education degrees shall contain a minimum of two years study of science, for those teachers in training opting for such study, should do much to dispel the lack of confidence in scientific explanation which may well have impeded progress previously. It is intended that such teachers shall be in the forefront of training other colleagues in their own school and the position of science co-ordinator for a school is seen as the appropriate role for these teachers now in training.

However, the move to introduce Technology to the Primary school curriculum is more problematic. The numbers of girl students taking the national examinations in 1982 in this field was 594 compared with 13,670 boys. An Oxford Research Group studying the teaching of technology in Secondary schools over a four year period has shown that girls' images of this area is firmly set by the age of 14; the traditional point in the English and Welsh system at which options to study particular subjects further are taken up. Their perceptions are that as a job 'technology is dirty, heavy work undertaken in male dominated situations'. The Equal Opportunities Commission report on Craft, Design and Technology strongly advocates CDT activities should be a part of every pupils experience in Primary and Middle Schools (9-13 years), and further, that CDT should be a Core Subject

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in the Secondary schools and compulsory in Girls Single Sex Secondary schools.[2] The problem here will be to obtain sufficient teachers to make this reality.

Similar pleas are being made for Science. It is certainly seen as a vital core element in the Secondary school curriculum and strong pressures from Her Majesty's Inspectorate for Education to give it the same status in Primary schools are apparent. The influential subject group, the Association for Science Education, is now publishing a journal specifically devoted to Primary Science: and in addition has set up as a national validating body to award Certificates and/or Diplomas in Primary Science. The intention of these is to update teachers' knowledge and to give them confidence to introduce science into their own classrooms, and maybe to become the science coordinator for their school.

Another powerful reforming force in the field of Science Education has been the setting up of the Secondary Science Curriculum Review. The intention of this body is to reformthe content of science syllabuses: the mode of operation has been to adopt a periphery to centre model. That is the teachers set up working groups to address a problem which they themselves have identified. It has led to important new initiatives to revise the syllabuses so that the material is less academic and becomes more related to today's world. It is notable that several groups chose the Equal Opportunity issue to investigate. The project has now reached the dissemination phase.

So the science curriculum of UK schools is set for rapid evolution to match the needs of the country in the 21st Century.

Research Programme

It seems more than ever imperative that we try to find out how young children react to science, in particular to identify the point at which their perceptions act against the interest of science in the curriculum. The study outlined is one of the few attempts to discover some of the facts in Primary schools.

Simpson has suggested that girls as young as 5-6 years can and do think effectively in a scientific context, being well able to make hypotheses, suggest ways to investigate these, and can successfully tackle the necessary experimentation. Possibly because they are advantaged in the use of language at this stage of their educational career.[3] Though they are quicker to suggest approaches initially and anxious to try out their ideas quickly; the slower thinking boys soon take over the programme at a practical level. If the girls can be encouraged to stand up against this nonsense, or alternatively to be put in a position where this is not necessary, they will achieve a very successful result.

Girdham's small scale research project[4] shows that girls are equally interested and enjoy science at 7-8 years, and are able to solve problems related to Movement and Energy in a scientific and technological context.

The strategies adopted to ascertain what girls thought about science and scientists were threefold:

1. A draw a scientist test.
2. A semi-structured interview.
3. An occupational stereotype inventory.

The responses of the children to these tests showed whether a positive or negative perception existed. To see how perceptions are reflected in willingness to be involved in scientific experiences 4 children were observed in a series of four problem solving episodes for a total period of 124 minutes using a one minute sample at three points in the lesson. A positive and negative respondent of each sex was chosen for this part of the study. The control for the experiment was to observe these same four children in lessons which did not involve science.

Of the 27 children in the study (15 boys, 12 girls) 87% of the boys and 58% of the girls drew figures which were male. The other attributes of the scientist were old, glasses, beard, white coat. 33% of the girls drew a feminine figure.

The semi-structured interview demonstrated that boys had more refined perceptions of the work a scientist undertook.

The occupational stereotype inventory showed that 85% of the boys would like to be a scientist, but only 27% of the girls identified it as a desirable occupation for themselves. Indeed 64% of the girls said firmly they wouldn't want to be a scientist. Nevertheless, of the 16 jobs listed in the inventory both boys and girls gave it third place.

The small observation sample showed that the interest and enjoyment in the science lessons was almost equal for both sexes (boys 85%, girls 79%). The control showed a similar pattern so it is probably an overall interest and enjoyment in all school activities rather than specifically in science/technology which has been demonstrated at 7-8 years.

Hadden[5] in an investigation of 1000 Scottish children at the Primary/Secondary school interface has found a similar positive attitude to science in young pupils of 9, 11 and 13 years of age. However he too detected the perception of the girls that 'Science is masculine'. Not surprisingly the boys had more positive expectations of science in relation to the job prospects.

The national 'Assessment of Performance Unit' which has sampled childrens' scientific achievements at 11, 13 and 15 years of age detected few differences between girls and boys. So, why don't more young women read physical sciences or technology in Higher Education? It should be pointed out that Physics is almost as unpopular with male students at Higher Education level, but that they regard it as a facilitating subject so are prepared to cope with it. Certainly at Advanced level General Certificate of Education (18+) most of the students are studying Physics to attain entry to other fields of endeavour, such as Medicine, Veterinary Medicine and Engineering.

Present research is extending the pilot study of Girdham so that a much larger sample can be obtained, and over a wider age range. A further extension of the research has obtained results from some 80+ children, one class of 5-6 year olds, one of 7-8 year old children and one of children in the top class of a First school (8-9 years).
The findings of the pilot study are confirmed.

Student teachers and practising teachers have agreed to cooperate and give a simple, less time consuming, test to the children in their classes so that eventually a profile of the perceptions of young pupils can be obtained from 5 years to 11 years. A nationwide sample however remains a hope for the future, but might be obtained through the good offices of staff on the widespread locations of the teacher training institutions around the UK.

Projecting into the Future

The upsurge of girls taking Physical Sciences subjects in the national examinations system is very encouraging but an equal movement is not detectable in Technology as shown by the examination entries for Craft, Design and Technology. Both scientific subjects and technological subjects are rapidly evolving to meet the needs of pupils for tomorrow's world: Both emphasise the problem solving approach, both the applications of 'pure' knowledge, and both the importance of an understanding of the methods appropriate to their respective disciplines.

Another cause for optimism is the fact that more and more students are entering the field of education for teaching and that the percentage

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of these who have studied science beyond the option plateau and therefore to a more advanced level is increasing. Once embarked on the teacher education course at Newcastle upon Tyne Polytechnic a high percentage of these students, both those on undergraduate Bachelor of Education degree and those on the Post Graduate Certificate of Education (Primary) are willing to introduce children in their practice classes to the pleasures of a study of science, and to include use of computers at a practical level with the children in their care. Finally these same students, predominantly female, are very aware of the strategies to combat the dominant male!

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RATIONAL GIRLS AND GIRLS' RATIONALITIES

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Research on women in scientific and technical studies has mainly delt with women's underrepresentation in these studies. A positive approach to women's position in the natural science subjects has been given little attention. In this study, girls in "hard" science subjects are compared to girls opting for "soft" subjects, especially focusing on reasons why they opt differently.

Reasons for the gender differences in subject options may be described as reasons to do with external factors (eg family support, school organization) and reasons to do with internal factors (abilities, values, attitudes). According to the latter type of explanations, girls' retention from "hard" science subjects is seen as a consequence of female characteristics, such as being emotional and personal, and having a rationality of caring. Boys' attraction to these subjects is understood as a consequence of their personality traits, being instrumental, impersonal and having a rationality of goal-directedness.

However, these explanations may be said to simplify and limit the understanding of the option behavior of both sexes. They concentrate on the mean of each sex, thus hiding differences between individuals of the same sex(Kelly 1982). A comparison of characteristics that distinguish girls in natural science subjects from girls in "soft" subjects may be a more adequate approach to the understanding of girls' attraction to or retention from the "hard" science studies.

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Physics as a "filter".

In Norway, special qualifications are demanded to study science and technology at university level. The students have to choose the science branch in the senior high school, as well as the advanced course in physics and mathematics. Students at this branch opting for biology and chemistry as their A-level subjects, are excluded from these studies, and thus from many prestigious and well-paid jobs. The students are taught in combined classes during their first year, and at the end of this year, they will choose branch and subjects for the remaining two years. The choice of physics may then be considered a critical choice.

Traditional and nontraditional girls.

In our study, girls opting for the nontraditional subjects (physics/math) are compared to the girls opting for biology/chemistry at the science branch. Several factors may influence on girls' option of nontraditional subjects:

How well a girl achieves in physics may be important for her choice whether to continue with it. According to Kelly(1986), students who continue with a subject are performing better than the average in it. It is reasonable to believe that girls who choose physics have better school results in this subject than the girls preferring not to study it. However, many girls are avoiding physics in spite of good performances:

Findings suggest that confidence in one's ability to learn science is an important motivated-related variable(Eccles 1984). Particularly physics is considered a difficult subject, and girls are more likely to avoid subjects because of difficulty as compared to boys

Boys are more likely to continue with physics than girls as they have greater confidence in their ability to learn physics(Kelly op.cit). There is little evidence to support whether girls opting for physics have more self confidence than the girls picking other subjects, but it may be assumed.

The two groups of girls may also be differentiated by attitudes towards physics. Girls choosing "hard" science subjects may be expected to have more positive attitudes towards physics, as well as an appreciation of it's utility, as in educational and career interest(Eccles 1984). This hypothesis also implicates that the nontraditional girls have a sex-role orientation being more radical than the traditional girls. This may be further examined when focusing on the girls' future plans.

Job aspiration may influence subject choice. In planning their future jobs, female students in higher technological education held the qualititative aspects with the job situation as more important than than career motives, as compared to their male fellow students(Kvande 1984). This analysis will reveal whether the nontraditional girls in the senior high school stress their motives differently when planning their future careers.

Family support has proved to have strong influence on women's tendency to choose nontraditional jobs(Houser and Garvey 1986). It is reasonable to believe that family background is of vital importance for girls' option of physics(Skog 1983). In this study we have, however, chosen to focus especially on "internal" factors, and will examine how school achievement, self confidence, attitudes towards science as well as future career motives influence on the subject choice. The comparison of girls in math/physics with the girls in biology/chemistry on these factors may be said to be of special interest, as both groups of girls have preferred the science branch, and thus a nontraditional branch in the senior high school.

Data.

In our study, data from the project "Equality ideals and curricular options" are used. A representative sample of about 1900 students in 18 senior high schools in Norway have answered questionnaires at the end of the first year (spring 1986). Information on their end-of-year results were collected from the schools.

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Few girls choose "hard" science subjects.

The choice of branch is strongly sex-stereotyped. Most of the boys (53%) chose the science branch, compared with only 27% of the girls. 56% of these girls have opted for the "hard" science subjects (151 girls), while the remaining 44% (115 girls) opted for chemistry/biology. Part of this difference may be explained by differences in achievement:

Nontraditional girls achieve better.

The table below shows the actual performance of the girls who have chosen to continue with physics compared to the girls preferring the traditional subjects.

Table 1. Actual performance in mathematics and natural science. Nontraditional and traditional girls.*

	Mathematics		Natural science	
Grade	%N	%T	%N	%T
(lowest) 1	0	1	0	0
2	5	7	1	3
3	5	14	6	12
4	24	38	22	30
5	52	36	56	50
(highest)6	14	4	15	5
N	151	115	151	115

*Difference significant beyond the 5% level.

These results suggest that girls opting for physics perform better than the traditional girls in both science subjects. But many girls who are performing well choose not to continue with physics. This study reveals that there is a potentiality of girls who will be able to manage physics, given support by "important others" in their lives(Houser and Garvey 1986). Thus, low marks can not explain girls' retention from "hard" science subjects, and there is a need for alternative explanations.

Nontraditional girls - confident girls.

The measure of self confidence is constructed by asking the students to evaluate their school results as compared to the rest of the class. The students were to choose among the following categories: much above the average, a little above the average, about average, a little below average or much below average. Their estimates were further compared to their real achievement. Table 2 shows the result of the comparison of the estimates of performance with the actual performance.

Table 2. The accuracy of nontraditional and traditional girls' estimates of their performance in natural science.*

	Natural science	
	%N	%T
Over-estimate	32	29
Accurate	56	46
Under-estimate	12	25
N	151	115

This table shows some marked differences between the two groups of girls in their estimation of their performance in science. While the nontraditional girls are more likely to be accurate in their estimation, the traditional girls have a tendency to under-estimate their performance. The girls who continue with physics thus seem to have more confidence in their ability in science than the girls in biology/chemistry. These results correspond to findings concerning gender differences in self confidence and it's effect on boys' option of physics(Kelly 1986)

*Differences significant beyond the o.o1% level.

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Rational girls.

Another explanation of the differences in subject choice between the girls may be different attitudes towards physics. Our study strengthens this hypothesis: 76% of the girls in "hard" science subjects stress the importance of getting more girls into physics, compared to 48% of the girls in the traditional subjects. The former group thus seem to be more liberal in their sex-role attitudes than the latter group, wanting more girls to enroll in a male-dominated field of study. This may be seen in the light of previous findings, showing that these girls are likely to have a strong self confidence, thus being less concerned with conforming to social norms. In reasoning why it is important that more girls opt for physics, the traditional girls tend to give "easy" answers, such as "to get sex equality". The nontraditional girls seem to have reflected more on this matter, mentioning the "talent loss", and arguing that "many girls have abilities in physics, but prefer other subjects". Their assumption is accordance with the situation uncovered in the achievement analysis (p. 4).

Two rationalities?

Whether the nontraditional and the traditional girls also may be differentiated by factors that are likely to affect the choice of future job are shown in Table 3.

Table 3. Motives influencing the choice of future job. % nontrad. and trad. girls who answer that each motive is "important".

	% N (N=151)	% T (N=115)
Career motives		
High income	55	32
Independence in work situation	58	47
Get a leading position	26	16
Social motives		
Do socially benefical work	31	34
Help other people	37	42
Care of family/children	29	26

The students were to choose among the categories "important", " a little important" and "not important" in their evaluation of motives, supposed to influence on the future job. In table 3, the proportion of nontraditional and traditional girls answering that each motive is "important", is presented. The motives are placed in the two categories, the *career* and the *social* group of motives, which may be said to correspond to the rationality of goal-directedness resp. the rationality of caring. It is hardly surprising that the nontraditional girls give greater weight to the *career* motives than the traditional girls. More unexpected is their tendency to evaluate the career motives as *more important* than the social motives. They stress more upon getting a high income and a leading position than doing a socially benefical work, thus evaluating in the opposite way as compared to the female engineer students (Kvande 1984). There are, however, no differences between the two groups of girls as far as the social motives are concerned. These results suggest that the career-oriented motives are not replacing the social motives, but may be regarded as additions to these motives. Thus, two types of rationalities seem to influence on the nontraditional girls' choice of future job.

Rational girls and girls' rationalities.

This study emerged from an interest in the study of girls opting for natural science subjects, as opposed to studies comparing girls with boys, where boys make the "norm" and girls are regarded as "deviants" from this norm. Our study revealed that the nontraditional girls achieve well, they are self-confident and they stress the importance of getting more girls to choose "hard" science subjects. Lack of confidence in their ability to study physics and negative attitudes towards the utility of physics may explain girls' retention from this subject. Favouring girls and increasing their self confidence seem vital for girls' attraction to physics.

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The girls in "hard" science subjects may be called rational girls, being mainly motivated by the career aspects with the future job. This study thus uncovers the limitations lying in the usual approach to women in natural sciences, where the rationality of goal-directedness is identified and described as a typical part of the male identity.

However, the rationality of goal-directedness is not replacing the rationality of caring. The social motives have a central position when the girls in physics are to choose their future job.

One reason why more women are wanted into science and technology is that they are supposed to express social values as well as technical knowledge. This study of girls opting for natural science subjects gives support to this assumption.

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RESEARCH WORK OF MEN AND WOMEN IN SCIENCE AND TECHNOLOGY

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1. INTRODUCTION

In the paper [1] prepared for GASAT 3 the participation of women in the studies and research work at A.Mickiewicz University (AMU) and Technical University (TU) Poznań, as well as the results of knowledge acquisition by students of physics were presented. It was stated that the contribution of women workers in research is high but depends on the branch of studies. It is the lowest in science (physics) and technology, and as far as the research posts are concerned, a decrease in participation of women in groups of higher professional qualifications was noted.

In this paper the attitude of the staff members of AMU and TU in respect to their own work in science or technology is presented. The questionnaire inquiry was aimed to reveal the difference between the sexes in: 1) experimental, theoretical and pedagogical skills, 2) interest and involvment in the subject of work, 3) cooperation abilities and attitude towards superiors, 4) involvment in pedagogical work, 5) opinion about equipment of the workshop and the effectivness of work, 6) the ways of reconciliation of proffesional work, family duties and social life, 7) estimation of the meaning of professional work in respondents life, 8) opinion as to the influence of one's work on the natural environment.

2. THE QUESTIONNAIRE, THE SAMPLE AND THE METHOD OF ANALYSIS

The questionnaire consisting of 75 items is given in Appendix 1. The items cover all the problems presented in Sec.1. The respondents were asked to give an answer to each item in 5-grade Likert scale: 1 - strongly agree, 2 - agree, 3 - difficult to answer (undecided), 4 - dissagree, 5 - strongly disagree. They were asked also to give some personal data.

Table 1

Characterization of the respondents. For every group the number of persons and the perventage (in brackets) are given.

<table>
<tr><td>Feature</td><td colspan="12">Groups distinguished for every feature</td></tr>
<tr><td>Sex</td><td colspan="6">40 (34%) Women</td><td colspan="6">78 (66%) Men</td></tr>
<tr><td>Period of employment</td><td colspan="3">0-10 years
31 (26%)</td><td colspan="3">10-20 years
60 (51%)</td><td colspan="3">20-30 years
19 (16%)</td><td colspan="3">over 30
8 (7%)</td></tr>
<tr><td>Post</td><td colspan="3">Assistant
16 (14%)</td><td colspan="3">As.lecturer
14 (12%)</td><td colspan="3">Lecturer
75 (64%)</td><td colspan="3">Professor
13 (8%)</td></tr>
<tr><td>Work place</td><td colspan="4">A.Mickiewicz U.
77 (65%)</td><td colspan="4">Technical Univ.
33 (27%)</td><td colspan="4">Other Univer.
8 (7%)</td></tr>
<tr><td>Character of work</td><td colspan="4">Experimental
53 (45%)</td><td colspan="4">Exp.-Theor.
48 (41%)</td><td colspan="4">Theoretical
17 (14%)</td></tr>
<tr><td>Number of childrem</td><td colspan="4">No childeen
18 (15%)</td><td colspan="4">1 or 2
86 (73%)</td><td colspan="4">3 or more
14 (12%)</td></tr>
</table>

We received 118 completly fulfilled questionnaires. The characteristics of the respondents is given in Table 1. Most of the respondents were physicists: 46 from AMU, from TU and

8 from other universities in Poland. The next group were chemists (21 persons), there were also some engireers, geographers and biologists. Nearly half of the staff of the physics departments at AMU and TU have fulfilled the questionnaire, so, we are sure that the results are representative for physicists

For every item the avarage value Xi and the standard deviation of the mean value Si were calculated (i - denotes the number of the item). For most items the responses are distributed all over 5 grades, but the average Xi is shifted from the middle value 3 (undecided) to the lower values - agree,or the higher one - disagree. The difference Di=Xi-3 between the average response to the item Xi and 3 is taken as a measure of the general tendency in the sample. Very low values of Di mean that most of the respondents are undecided (item 68), or that their responses are symmetrically distributed as e.g. items 11, 12, 32. The standard deviation of the mean value for a single item is changing from 0.05 to 0.11 with the mode of 0.08 The factor analysis and the t-test for sex differences were made for the whole questionnaire [2].

3. FACTOR ANALYSIS AND SEX DIFFERENCES

26 valuable factors with eigenvalues greater than 1 were distinguished. They covered 83.7% of the total variance. The first 9 factors with the eigenvalue greater than 2 covered 43.7% of the total variance. These 9 factors were easy to indentify and to give them the name. Most of the factors of the order greater than 9 are represented by few items, in some cases by one or two, so we may suppose that these items were really independent (orthogonal). Most of the problems stated at the beginning (Sec.1) are found in the first 9 factors. But still the factor analysis revealed a new factor

(factor number 2 in sec.3)"attitude towards the work of women and towards teaching". Thus actually the problem of women in science research and university teaching has been found as one of the most valuable factors. The t-test was applied to analysis of sex differences. It gives significant differences for 25 items. The difference X_i in the avarages for responses given by women and men may be taken as a measure of the sex difference $Y_i = X_{iw} - X_{im}$ where X_{iw} and X_{im} denote the avarage responses for item number i given by women and men, respectively. For many items the difference (Y_i-value) is relatively great, it exceeds 0.5. The standard deviation of the mean value for X_{iw} varies between 0.08 and 0.18 with the mode of 0.14 for women and for X_{im} between 0.05 and 0.14 with the mode 0.9 for men.

4. DISCUSSION OF THE RESULTS

Factor 1: "Involvment in professional work" (items 2, 33, 60, 15, 61, 13, 34, 41, 66, 5, 23, 30, 69, 74)[1]

Most of the respondents appreciate the great value of science for technology development (D30=1.5). They evaluate the work in science as interesting (D33 = 1.4), and most suitable for them (D23 = 0.6, D61 = 0.7) which gives them pleasure (D60 = = 1.1, D66 = 0.8). Scientific work compels them to improve their qualifications (D41 = 1.5) and follow the latest achievments (D13 = 0.9). They respect the work of others (D5 = 1.4) they work not only because of the necessity (D74 = 0.8) and are interested in the work of their coworkers (D69 = 0.7).

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[1] The number of items are given in order of decreasing contribution to the wariance. Items with contribution greater than 0.5 are underlined.

Sex difference have a significant value only for a few items of factor 1. The differences are pointing to greater involvment of men (Y61 = 2.7 - 2.2). They consider their work more as a life-time objective and as the most suitable job (Y23 = = 2.7 - 2.3) and are more intensive in following the latest achievements (Y13 = 2.3 - 2.0).

Factor 2: "Attitude towards the work of women and towards teaching " (items 29, 65, 73, 38, 75, 6, 45, 50, 62). Teaching is not preferred as compared with research (D6 = 0.5) even so, is liked (D62 = 0.5). Present great actual employment of women is accepted (D75 = 0.0) and the opinion predominates that women are equal to men in research (D65 = 0.2) and should be equaly engaged in research (D29 = 0.2).
Very interesting result is that no significant sex difference was registered in items: 50, 29, 65, 73 which are essential for the attitude towards work of women. The greatest difference is registered for item 75 (Y75 = 3.4 - 2.8) which indicates that women have positive attitude towards their participation in science research and men slightly negative The difference (Y45 = 3.1 - 2.5) indicates that in men's opinion men are better students in science.

Factor 3: "Experimental and practical skills and creativity" (items 21, 71, 32, 24, 18, 25, 27, 55).
There is a generally positive opinion about creativity (D27 = = 0.7) and readiness to help the coworkers (D18 = 1.0). The researchers repair minor failures of equipment in laboratory (D21 = 0.4) and at home (D71 = 0.5).
In this factor the greatest differences for women and men were registered in most items. Women do not repair equipment as often as men at home (Y71 = 3.1 - 2.1) and laboratory

(Y21 = 3.2 - 2.3) and do not improve the measuring devices (Y32 = 3.4 - 2.7). They are not so keen to help the coworkers (Y12 = 2.2 - 1.8) as men do, not so creative (Y27 = 2.4 - 1.9) and strongly not interested in supervision (Y55 = 4.5 - 3.6).

Factor 4: "Reconcilation of proffesional work and family duties" (items 19, 52, 67, 3, 55, 64).

It is difficult to balance research work and family duties (D19 = 0.4) and the latter are responsible for a delay in research work (D52 = 0.2). There is a lack of time for studying papers (D3 = 0.5) and not enough money D67 = 0.6 .

Most people are not interested in work as a supervisor (D55 = = 0.9).

It is intersting that no significant sex difference is registered in item 19, whereas for women family duties are the reason of delay in their research (Y52 = 2.3 - 3.1)and men are interested in higher salary (Y67 = 3.8 - 3.4).

Factor 5: "Cooperation abilities in profession and family work" (items 8, 49, 28, 30, 5, 54).

Very optimistic result is that one can rely on his coworkers (D49 = 0.9) and in his work he finds friends (D28 = 0.9) and men are engaged in family work as well (D8 = 0.8).

The only one significant sex difference is connected with home duties (Y8 = 1.9 - 2.4).

Factor 6: "Evaluation of experimental and theoretical work" (items 59, 1, 72).

Most of the experimentators (absolute majority of the respondents see Tab.1) are conscicus of the difficulties of theoretical work (D59 = 0.5) and they do not prefere it (D1 = 0.1)

Factor 7: "Social value of work" (items 12, 22, 24, 38).

Evaluation of the social value of work is not satisfactory since we do not find negative responds for item about the waste of goods (D12 = 0.1) effectivness of work (D22 = 0.1) usefulnes respondents work (D38 = 0.1) or favour of one esx (D24 = 0.1).

Factor 8: "Positive evaluation of work" (items 56, 54.73,64). The greatest number of respondents think that the results of their work are of good quality (D56 = 0.5) but they are not content with them (D64 = 0.1) and they do not see the usefulness of their work (D54 = 0.1).

Factor 9: "Difficulties in work" (items 7, 17, 3, 56). The equipment in laboratory is not satisfactory (D7 = 0.8) literature is hardly avaliable (D17 = 0.8) and there is a time shortage (D3 = 0.5).

There are also some significant sex differences in following other items not strictly connected with factor 1-9. Men are more sure that their work does not cause any deterioration in the natural environment (Y34 = 3.8 - 4.4) and that modern technology does not destroy the environment (Y10 = 2.9 - 2.1). Women are not so strongly interested in the coworkers activities (Y69 = 3.4 - 3.8). Very peculliar is the results of item 72 which indicates that women do not care so much for the esthetis form of the product as men do (Y72 = 3.3 - 3.8). Women are more dissatisfied with or the equipment (Y7 = 4.1 - 3.7) and (Y42 = 2.9 - 2.3) do not travel abrocal as often as men.

5. FINAL REMARKS: ACKNOWLEDGEMENTS

It should be underlined that our results are not representative for other jobs e.g. in technology and for workers in factories. In the future it will be very interesting to start an international study of this problem. Our research may be treated as a starting point for such study.

The authors wish to thank professor Jan Raat from Technical University in Eindhoven for the computer processing of our results.

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Appendix 1

Questionnaire (Av - average, SA - strongly agree, A - agree, U - undecided, D - disagree, SD - strongly disagree)

Item	Av	SA	A	U	D	SD
1. I prefer theoretical work to experim.	3.14	16	15	30	51	6
2. I like to undertake difficult tasks	2.31	18	56	36	6	2
3. I have enough time to read literature in the branch of my specialization	3.50	2	27	13	62	14
4. I prefer to employ man as a coworker in my research group	2.33	24	47	34	10	3
5. I respect the work of others	1.57	55	59	4	-	-
6. Teaching is for me as important as the research work	3.51	2	9	42	57	8
7. The equipment in my laboratory is satisfactory enough to carry out my research work	3.79	2	18	10	61	27
8. A man and women should be equally engaged in upbringing of children and home duties	2.22	24	59	21	13	1
9. Many difficulties are on purpose put in my way at work	3.60	5	13	20	66	14
10. Due to the modern technology applied I do not have to destroy natural environment	2.38	37	38	11	25	7
11. The subject of my work is a consequence of practical needs	3.02	6	36	37	28	11
12. A lot of goods and materials are wasted in my laboratory	3.10	7	26	36	46	3
13. I try to get acquainted with the latest achievments in science	2.09	15	85	11	7	-
14. My superiors favour women in research work	3.82	3	33	64	18	-
15. I work only under necessity to get money	3.94	4	11	8	60	35
16. Computers become the basic tool in education	2.83	10	40	35	26	7
17. The latest literature on the subj. of my speciality is hardly available	2.17	36	53	7	17	5
18. I am ken to help my coworkers	1.95	21	84	12	-	1

Item	Av	SA	A	U	D	SD
19. It is difficult for me to balance my family duties and my research work	2.55	14	53	23	28	-
20. Development of science is a vital necessity of mankind	1.95	51	38	16	10	3
21. I repair minor failures in my laboratory equipment by myself	2.61	12	59	15	27	5
22. In my group there are not very effective people whose work is made up by others	3.09	6	30	36	39	7
23. I could find no better work for myself than in researches	2.43	19	44	40	15	-
24. The coworkers favour men in research work	2.94	7	30	45	35	1
25. I am avare that a part of my work will be useless but I still do it	2.36	14	65	23	14	2
26. I highly appreciate the results of application of TV and film in education	2.77	4	55	28	26	5
27. I can be highly creative in my work	2.03	22	78	11	6	1
28. I have made friends at my work place	2.14	16	74	24	4	-
29. Women and men should be equally engagrd in research work so as to prove their intellectual capabilities are the same	2.80	8	40	43	21	6
30. Science development determines the level of technology	1.52	65	45	8	-	-
31. I work efficiently in the whole time of my duty hours	2.84	7	48	23	37	3
32. I work myself on improvement of the meesuring equipment	2.97	5	48	16	44	5
33. The work connected with research is interesting	1.60	51	63	4	-	-
34. The results of my work cause deterioration of the natural environment	4.20	1	5	10	55	47
35. Teachers favour men from among stud.	3.53	1	10	44	52	11
36. Traditional teaching methods are relatively ineffective	3.16	29	49	32	8	-
37. My work contributes to know the world better	2.15	14	76	24	4	-

Item	Av	SA	A	U	D	SD
38.My research work is useful for soc.	2.95	5	24	66	18	5
39.Research work gives the opportunity to meet interesting people	2.27	12	70	29	6	1
40.Objective obstacles e.g.attempts to get better equipment,delay my research work	1.91	39	64	5	7	3
41.My work requires permanent improvement of my qualifications	1.58	53	62	3	-	-
42.My work gives me the opportunity to go abroad	2.49	10	64	23	18	3
43.The relations in my group discourage me in my work	3.16	5	29	32	46	6
44.The motives beyond the merits of my work (religion,phylosophy) influence my attitude to work	3.54	6	21	16	53	22
45.Men are better students of science	2.71	13	32	49	24	-
46.I have free time for the activities other than my family and work duties	3.41	1	32	17	54	14
47.I devote more time to research work then to didactics	2.42	17	57	26	13	5
48.I use a computer or want to use it in my future work	1.80	39	69	6	3	1
49.I can rely on my coworkers in case I need help	2.12	19	75	16	7	1
50.Women are good supervisors of research works	2.87	9	33	46	24	6
51.I know one western language	1.99	20	85	9	2	2
52.My family duties are the reason of much delay of my research work	2.83	4	44	27	34	4
53.Teaching is much easier than the research work	3.09	2	31	46	32	7
54.My work serves to adjust the world to peoples needs	2.93	3	32	57	22	4
55.I am interesting to work as a supervisor of a research group	3.90	-	12	16	62	28
56.The results of my work are not worse than the results obtained in other research centers	2.53	8	63	26	19	2

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Item	Av	SA	A	U	D	SD
57. I appreciate the capability to work as it distinguished people	1.85	34	69	14	1	-
58. I choose my work as I was good at science	2.14	22	70	15	10	1
59. Experimental work creates much more problems than theoretical work	3.48	6	13	31	55	13
60. I do my work with pleasure	1.91	26	76	16	-	-
61. I consider my work as an life-time objective	2.34	17	57	32	11	1
62. I like teaching	2.50	9	63	27	16	3
63. If I were a supervisor of my group I would introduce many improvements	2.59	10	38	60	10	-
64. I am content with the results of my work	3.14	1	31	39	44	3
65. Women by nature are not equal to man in research work	3.15	5	24	43	40	6
66. My work gives me the joy of creativity	2.15	13	77	25	3	-
67. Low salary makes me think of changing my job	3.56	4	10	28	68	8
68. I think I am a good teacher	2.94	1	23	77	16	1
69. I am not interested in the work of the other workers of my division	3.66	-	11	26	73	8
70. I do not think my work sensible	3.64	-	16	24	65	13
71. I often fix home equipment myself	2.50	13	68	7	25	5
72. I disregard the aesthetic side of the products of my work	3.63	3	16	21	60	18
73. I think that more women should work in science	3.37	4	10	46	54	4
74. I work as much as it is necessary to keep the post	3.84	-	11	17	70	20
75. I disapprove of a great number of women in profesional work	3.02	12	29	32	35	10

ISRAELI HIGH SCHOOL BOYS AND GIRLS ACHIEVEMENT AND ATTITUDES TOWARD SCIENCE

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The differences between boys' and girls' achievement in and attitudes toward science learning has received a lot of attention in recent years. Findings of many studies all over the world indicate that with regard to science boys a) achieve better; b) have more positive attitudes; c) express higher interest in school as well as out of school learning; d) have a stronger inclination to choose science as a career; and e) have a higher preference for the physical sciences (e.g. Comber and Keeves, 1973; Gardner, 1985; Johnson and Murphy, 1986; Kahle, 1985; Kelly, 1981).

While the picture drawn above does reflect the general state of the art the reasons for the gender differences are not fully understood. One way to gain deeper understanding of the factors which create the differences between boys and girls is to carry out comparative studies involving different educational systems. If, for example, girls achieve as well as boys in certain systems but not in others, it may be possible to identify the factors which account for the difference and find out the conditions of learning which are more favorable to girls.

In this report we focus on gender differences found among Israeli 17 year old students within the framework of the Second International Science Study (SISS) conducted under the auspices of the International Association for the Evaluation of Educational Achievement (IEA). However, we begin by a brief review of previous pertinent research.

Several studies have reported on gender differences related to science learning in Israel. Tamir, Arzi and Zloto (1974) found that while 12th

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grade girls had less positive attitudes toward physics "they refused much more strongly than boys to adopt the image of physics as a masculine subject and to view girls doing physics as less feminine." Another interesting and unexpected fining is that girls were much more convinced that "lectures are not the most effective way to teach physics" and that "the laboratory is indispensable in the teaching of physics." This finding appears to contradict Walberg's (1967) assertion that "girls have very low interest relative to boys in tinkering with equipment at home or in the laboratory" and that "therefore it may be necessary to reconsider the appropriateness of the laboratory experience as a pedagogical method for girls" (p. 115). While tinker with equipment at home indeed appears to be a boys' domain (e.g. Johnson and Murphy, 1986) the relative effectiveness and attractivity of the school laboratory for girls remain an open question.

Hofstein and Ben Zvi (1985) compared the attitudes of 8th and 11th grade boys and girls toward various aspects of science. They obtained similar results at both grade levels. There were no differences in attitudes toward science and scientists. As to school science there were no differences either in the perception of the relevance of science learning to everyday life, or about the effort required to study science. However boys' attitudes were significantly more positive regarding the following: extra-curricular activities (1/2 standard deviation), it is interesting to study science (1/3 standard deviation), science studies contribute to self confidence (1/3 standard deviation) and choice of science career (1/6 standard deviation).

Ben Zvi, Scherz and Hofstein (1985) found substantial differences between 10th grade boys and girls in their choice of subjects for specialized study in the junior and senior years in high school, as follows: Girls constituted 73% among those elected to study no science, 62% among those electing biology, 49% of those electing chemistry and 27% of those electing physics. 10th grade boys have more positive attitudes toward science, they regard more highly the importance of science and scientists, more of them aspire for a science career and many more intend to pursue a career in technology.

The results reported so far dealt mainly with attitudes toward the physical sciences. With regard to biology, it has already been reported that more girls choose to study it in high school. In addition it was found that girls show a higher preference for the study of plants while there are no differences regarding zoology or human biology (Tamir and Jungwirth, 1974). As far as achievement is concerned, in the physical science, 10th grade boys exhibited, on the average, high achievement (Ben Zvi, Scherz and Hofstein, 1985). In biology, on the other hand there were no gender differences by the end of the 10th grade either in biological knowledge or in process skills (Tamir and Jungwirth, 1975), or in understanding the nature of science (Jungwirth, 1968). As to achievement in the 12th grade, girls achieved better in plant identification (Tamir, 1972), in botany (Tamir, 1974) as well as in measures which assess understanding and dealing with process skills (Tamir and Jungwirth, 1975). More recently it was reported that in the biology matriculation examinations boys achieved better in a few multiple choice items but there were no differences between boys and girls either in most multiple choice items or in open problem solving questions, or in analysis of unseen research report (Tamir, 1985). Lastly with regard to information processing in biology it was found that at the 12th grade girls were more oriented toward fundamental principles while boys were more oriented toward critical questioning and application (Tamir, 1975).

Based on the sort of data mentioned above as well as on data pertaining to factors which affect subject and career choices by boys and girls

(Tamir and Gardner, 1987) it may be concluded that the behavior of boys and girls in relation to science is multidimensional and multidirectional. There are indeed differences between boys and girls; however, there is no basis for assuming that all these differences are in favor of boys. Instead it is possible to identify certain features which clearly distinguish between "boys' science" on the one hand and "girls' science" on the other. These differences which have been established by many many studies all over the world are summarized by Tamir (1987). The study reported here was conducted as a part of the Second International Science Study (SISS) which was carried out in 26 countries in the years 1983-1984. The aim of SISS was to assess the science achievement, attitudes, interests and preferences of students as related to a variety of home and school variables. Three populations were studied: 10 year olds, 15 year olds and 17 year olds.

In this report we focus on gender differences found in the 17 year olds' sample in Israel. The sample (N = 68 schools, 137 classes, 2153 students) represents the population of students who sit for matriculation examinations at the end of their high school studies (year twelve). In Israel all the students follow a common curriculum till the end of year nine which is the last year of the lower secondary school. At the higher secondary school students choose certain subjects on which they are examined by external examinations at the end of year twelve. These examinations are known as the matriculation or "Bagrut". In every subject lower as well as higher level examinations are offered. Usually a particular student will choose only one high level science (biology or chemistry or physics) or no science at all. Our sample includes all four groups which will be designated as biology, chemistry, physics or non-science majors.

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Purpose

The purpose of the present study is to examine gender differences as related to the following variables:

1. Subject choice at the higher secondary school.
2. Achievement in biology, physics and chemistry.
3. Attitudes toward science.
4. Understanding the nature of science.
5. Cognitive preferences.
6. Socio economic status.
7. Attitudes toward science learning.
8. Attitudes toward learning and school.
9. Interest in biology and inquiry experiences.
10. Self-perception of achievement in science and mathematics.
11. Science related career orientation.

Method

The following instruments were used: 1) a background questionnaire which provided information about the home and school environment as well as on personal matters such as liking of science, time devoted to homework and career orientation; 2) 5 achievement tests: a general science test, a biology test, a chemistry test, a physics test, and a science test administered only to non-science majors; 3) a 40-item attitude scale; 4) a 20-item Understanding of Science Measure; 5) a 20-item Cognitive Preference Inventory; 6) a 40-item questionnaire on instructional strategies and learning experiences in school science.

The various tests and questionnaires were administered by the classroom teachers in the last quarter of the academic year, either in the year 1983 or in 1984.

The data were analyzed by SPSS programs using a variety of statistical procedures.

Results and Conclusions

Major subject choice: The percentage of girls majoring in each area was: biology - 61, chemistry - 49, physics -31, non-science - 66. It may be seen that girls outscore boys as non-science or biology majors while boys outscore girls in physics. About an equal number of boys and girls choose chemistry.

Achievement: Boys outscored girls in the general science test but the major determinant of their superiority was their achievement in physics where the difference is close to a half of a standard deviation. A higher mean score in Application was also noteworthy. It could be argued that the higher achievement of boys in physics may be accounted for by the larger number of boys majoring in physics (69% of the physics were boys). However this explanation is only partially correct. When we compare the performance of boys and girls who major in physics the difference is much smaller, (only one quarter of a standard deviation) but still statistically significant.

In the physics tests taken only by physics majors the boys again outscored girls in all areas the difference in the total test amounting to a half of a standard deviation. Again the boys excelled in Application more than in Comprehension and Knowledge.

Because of space limitations we cannot report the detailed results of the remaining tests.

The results of the achievement tests lead to the following conclusions:

1. Boys excel in physics, under all circumstances.
2. Boys excel in Application in all the sciences except biology.
3. There are no differences in achievement in chemistry between boys and girls who major either in chemistry or in physics or in biology.
4. Although overall boys and girls who major in biology achieve equally well there are certain topics in which girls excel and others in which boys excel. Girls tend to excel in Application, especially in topics related to human biology.
5. Non-science students enter life quite illiterate in basic scientific knowledge. The girls are especially poor in science literacy.

Attitude toward science: While there were no differences regarding the extent to which science is harmful - girls and boys equally do not perceive science as harmful, boys,on the average,feel that science is more important to society and to themselves personally. As shown later this attitude is indeed confirmed by their career choices.

Understanding the nature of science: Although both boys and girls exhibit a high level of understanding boys reveal a somewhat higher level. However the difference is very small (less than 1/5 of a standard deviation).

Cognitive preferences: No differences could be found between the preferences of boys and girls to any of the four cognitive modes. Both groups reveal the highest preference for principles, followed next by application, memorization and critical questioning respectively.

Socio economic status (SES): On the average the SES of boys is higher than that of girls. This implies that more girls of lower SES elect to major in science in high school. This is an interesting finding which is likely to be associated with the tendency of lower SES boys to enroll in vocational tracks which do not lead to matriculation examinations.

Attitudes toward science learning: are represented by the following :

Interest and motivation (an aggregate variable consisting of items such as "I like to learn more about the world," "I like to apply scientific knowledge," "I look things up in books other than school books"), Liking to study science and Time spent on science homework.

In all three items boys exhibit a higher mean score.

In addition boys also like more than girls to study math, which is positively correlated with liking to study science. It may be concluded that boys have on the average more positive attitudes to the study of science.

Attitude toward learning and school: Girls are more devoted students, spend more time on homework, concentrate more and seek more help in their study at home. It may be concluded that girls have on the average more positive attitudes toward school learning.

Interest in biology and inquiry experiences: Girls are more interested to study biology and report more inquiry experiences in the laboratory lessons. These results may be explained by the higher proportion of girls who major in biology and the lower proportion of girls who major in physics. Obviously these proportions will lead to a higher level of interest of girls in the study of biology. Since inquiry in Israel is much more frequent in biology than in physics laboratory lessons, the gender proportions also explain why girls report a higher level of inquiry in lab.

Self perception of achievement in science and math: The students were asked whether their grades in science/math were lower than in other school subjects,equal to other subjects or higher than in other subjects. The data clearly show that more boys perceive themselves as higher achievers in science and in mathematics.

Science related career orientation: Almost perfect match exists between subjects chosen for further study and career orientations. While substantially more boys plan to study science oriented subjects and choose science oriented careers, a more detailed analysis reveals that the differences hold for natural sciences and engineering but not for medicine. In fact 12% of the girls compared with 11% of the boys aspire for medical careers. The very low percentage of girls electing engineering is especially conspicuous. The findings can be summarized as follows: Out of every hundred boys who major in science in high school 70 will continue with science oriented studies at the university, 33 will major in the natural sciences, 16 in engineering and 11 in medicine. For girls the corresponding figures are 55, 21, 4 and 12 respectively.

Conclusions

1. Girls in general are less interested in studying science, have less positive attitudes toward science and toward science learning, have less

understanding of the nature of science and are less inclined to continue to study science in college. On the other hand they have more positive attitudes toward school learning, school is less boring for them and they invest more time in their homework.

2. More boys specialize in high school physics, boys consistently achieve better in physics,are better able to apply their physics concepts, more of them aspire for scientific research careers and,most notably,engineering careers. On the other hand girls are more interested in biology,more girls specialize in high school biology, they tend to apply better their biological concepts, they achieve better in certain topics such as genetics and human biology and relatively more girls who aspire for science oriented careers choose medicine.

3. A very low level of scientific literacy was found among non-science girls who represent the majority of our future mothers.

4. The underachievement in physics of girls,including those who elected to specialize in physics,is puzzling and requires further study.

5. With the exception of problems related to the study of physics, high school science in Israel reveals no bias against girls. In light of this another puzzle is why so few girls aspire for a science related career. Attracting more girls to science careers is certainly a national priority.

6. Countries in which boys achieve better than girls in biology and chemistry may benefit by examining the Israeli setting which turned both chemistry and biology to "non-sexist" science subjects and, hence, may provide clues for improving the achievement of their girls in these subjects.

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The Effect of Same-Sex Role Models on Perceptions of Performance in Science Courses

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"Our children and our students are participants in a complex process that equips one sex with math, and technical skills indispensable to functioning in the adult world, while it fails to encourage the same development in the other sex (Skolnick, Langbort, & Day, 1982, P. 2)."

Relying on the data from the Universtiy of Jordan Statistical Yearbook (1980), we can observe that while the proportion of men who eventually graduated was only slightly greater than the corresponding proportion of women (55% to 45%), there was much greater sex imbalance in particular disciplines. For example, in 1980, women constituted only 25% of the students in engineering and technology, a ratio of 1 to 4. Men were much more likely than women to major in physics and chemistry as well (ratios of about 5 to 1), while women were as likely as men to major in biology.

Likewise, the National Science Foundation (1984) indicated that, in the United States in 1981, although half of undergraduate students were women, women represented only 35% of. all science and engineering degrees. Similar assessments were almost found in every country. For example, in Poland in 1981, women represented only 30% of fourth-year students in technical programs (Chivers, 1984).

Over the past two decades, a considerable amount of research has investigated sex differences in ability and performance in natural sciences and mathematics (e.g.,Fennema, 1982). The research documented large discrepancies between men and women in career interests and occupations in the natural sciences (Cole, 1979).

Maria Mitchell revealed a persistent barrier to women in science, namely, sex-role stereotype of women as emotional, artistic, and delicate which suggests that they are not suited to science. On the contrary, sex-role stereotype of men as logical, analytical, and rigorous used to describe science as masculine. Sex-role stereotyping, however, is a societal factor affecting the role as well as the status of women in natural sciences and mathematics (Kahle, 1984). It is anticipated that if effort is made to bring women into these areas, this stereotype will diminish; and hence, will lead to equity between men and women with regard to perceptions of performance in these areas. This study aimed at examining the following hypothesis: "Having instructors of the same sex in introductory science courses as role models improves the perceptions of performance of students in science courses." While there is some evidence that both women and men instructors encourage boys more than girls in mathematics (Becker, 1981), the presence of female role model is crucial to the success of college women in traditionally male areas and hence, make women feel that success in these areas is both possible and legitimate.

METHOD

Data Collection

The study was conducted by distributing a questionnaire to all sophomore chemistry, physics, and biology students at Yarmouk University, Irbid, Jordan at the beginning of fall semester. The questionnaire covered the following variables: Sex of student, major, mathematics courses studied at university level and grades on these courses, science courses studied, sex of instructor, and perceptions of performance in each course. The latter variable included: Assessments of the degree of difficulty of the course, the degree to which the student understood the instructor, the student's performance relative to classmates, and preparedeness for the course.

At the completion of data collection, the authors found it necessary to control for mathematics background since previous studies (e.g., Sells, 1980) identified this factor as a critical filter that screens out women from science and engineering majors. In this study, therefore, it was deliberately attempted to control this factor by selecting only students with about the same mathematics background. Out of 170 participants, 150 had about the same mathematics background.

Sample

The participants were 150 (69 men and 81 women) sophomore students majoring in chemistry (28 women and 23 men), physics (37 women and 12 men), and biology (16 women and34 men) at Yarmouk University, Irbid, Jordan.

RESULTS

To investigate the effects of having had a role model on perceptions of performance in science courses, women and men students in this study were divided according to whether their science teachers had been male as opposed to being female. Table 1 presents results of multivariate tests of significance concerning student perceptions of their performance in biology, chemistry, and physics. Neither the main effects of the teacher sex and the student sex nor the interaction effect were significant at $\alpha = 0.05$ ($F < 2.3$ in all cases) for biology. However, this is not the case for chemistry and physics. The main effect of teacher ($F = 3.398$ for physics and $F = 2.684$ for chemistry), but not of student sex ($F < 2$ in both cases), was significant at $\alpha = 0.05$. Moreover, there were significant (teacher sex X student sex) interaction effects at $\alpha = 0.01$ for physics and chemistry ($F = 4.392$ and 5.386) respectively.

Univariate F-tests were then conducted on the four measures of perceptions of performance; namely, difficulty of course, performance relative to classmates, percentage of time understood instructor, and preparedness for course. Tables 2, 3, and 4 present univariate F-tests for biology, physics, and chemistry respectively. Table 2 indicates that for biology, main effects of the student sex factor and the teacher sex factor were not significant at $\alpha = 0.05$ ($F < 2$) in all cases. None of the interaction effects (for biology) was significant at $\alpha = 0.05$ except one. 71.4% of women, compared to 50% of men, in biology with female instructor claimed to understand the instructor most of the time; whereas, 63.6% of men, compared to 51.6% of women, in biology with male instructor claimed to understand the instructor most of the time ($F = 5.3793$, $P < .05$).

Table 3 reveals a significant main effect of the teacher sex on the difficulty of course ($F = 7.3975$, $P < .01$). 50% of the students in physics with male instructors felt the class was hard, compared to only 25.25% of the students in physics with female instructors. Moreover, table 3 reveals a significant main effect of the student sex on the perception of performance relative to classmates ($F = 4.7593$, $P < .05$). 18.2% of men, compared to only 9.7% of women, in physics claimed to perform better than their classmates. Furthermore, the table reveals two significant teacher sex X student sex interaction effects at $\alpha < 0.01$ on the difficulty of course ($F = 7.5658$) and the percentage of time understood instructor ($F = 6.4137$). 32.3% of men students, compared to only 18.2% of women students, in physics with female instructor felt the class was hard, whereas 50% of women, compared to 0% of men, in physics with male instructor felt the class was hard. Likewise, 36.4% of women, compared to 28.7% of men, in physics with female instructor claimed to understand the instructor most of the time, whereas 47.1% of men, compared to 23.8% of women, in physics with male instructor claimed to understand the instructor most of the time.

Table 4 reveals significant main effect of the teacher sex on: The difficulty of course ($F = 4.6861$, $P < .05$), the performance relative to classmates ($F = 7.5604$, $P < .01$), the percentage of time understood instructor ($F = 7.6517$, $P < 0.01$), and the preparedness for course ($F = 4.5$, $P < 0.05$). 77.35% of chemistry students with male instructors, compared to only

35.45 of chemistry students with male instructors, felt the class was hard. Moreover, 77.35% of chemistry students with female instructor, compared to only 26.6% of chemistry students with male instructors, claimed to perform better than their classmates. Furthermore, 35.45% of chemistry students with female instructor, compared to 27.35% of chemistry students with male instructor claimed to understand the instructor most of the time. The last indicator, the preparedness for course, showed that 60.7% of chemistry students with female instructors are better prepared for the course, compared to only 42.85% of chemistry students with male instructors.

Table 4 indicates that main effect of the student sex on variables of perceptions of performance in chemistry was not significant at $\alpha = 0.05$ ($F < 3.1$ in all cases). However. there were three significant teacher sex X student sex interaction effect on difficulty of course ($F = 8.927$, $P < 0.01$), performance relative to classmates ($F = 8.626$, $P < 0.01$), and percentage of time understood instructor ($F = 5.497$, $P < 0.05$). 47.1% of men, compared to 23.8% of women, in chemistry with female instructor felt the class was hard; whereas, 71.4% of men , compared to 83.3% of women, in chemistry with male instructor felt the class was hard. Moreover, 29.4% of men , compared to 23.8% of women, in chemistry with male instructor believed themselves as performing better than their classmate; whereas, 83.3% of women, compared to 71.4% of men, in chemistry with female instructor believed themselves as performing better than their classmates. The final indicator, the percentage of time understood instructor, showed that 47.1% of women, compared to only 23.8% of men, in chemistry with female instructor claimed to understand the instructor most of the time; whereas, 42.9 of men, compared to only 11.8 of women, in chemistry with male instructor claimed to understand the instructor most of the time.

Discussion

The analyses of the data indicated that when mathematics background was controlled, teacher sex had effects on perception of performance in physics and chemistry but not in biology. Female instructors, more than male instructors, encourage students to feel chemistry and physics classes as easy, claim better performance in chemistry relative to classmates, claim better understanding of the chemistry instructor, and be better prepared for chemistry course.

Moreover, the analyses revealed role model effects in physics and chemistry, but not in biology. Female chemistry and physics instructors encourage women students to perceive chemistry and physics as easy and to understand the instructor most of the time. Also, female chemistry instructors encourage women students to perform better than their classmates. On the contrary, male chemistry and physics instructors encourage men students to perceive chemistry and physics as easy and to understand the instructor most of the time. Also, male chemistry instructors encourage men students to perform better than their classmates. It follows that the role model hypothesis was confirmed with regard to chemistry and physics but not to biology. Moreover, for chemistry and physics, the role model effects for female instructors were stronger than those for male instructors. Hence, the presence of a female role model is crucial to the perception of performance of women in traditionally male areas (chemistry and physics). In other words, the presence of a female role model makes college women perceive that succes in chemistry and physics is both possible and legitimate.

The absence of significant main effects as well as role model effect for biology indicates that men and women students do not differ in their perception of performance in biology. Moreover, the teacher sex has no effect on student's perception of performance in biology. Furthermore, the presence of a female role model is not crucial to the perception of performance of women students in biology. This may be explained in terms of the notion that women are as likely as men to major in biology because women perceive that their success and competence (with men) in biology is legitimate since it compromises with society's expectations.

Clearly, the findings of the present investigation are by no means final due to the limitation of the small sample size. However, this study could well provide a stimulus for further research of the fundamental issue regarding the effect of same-sex role model on the perception of performance in science courses.

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Table (1)

Multivariate Tests of Significance Concerning Student Perceptions of Performance in Biology,Physics, and Chemistry

	Effect:Student Sex F ratio	Effect:Teacher Sex F ratio	Effect:Teacher Sex X Stu.Sex F ratio
Biology: Pillais	1.866	2.2306	1.849
Hotellings	1.866	2.2306	1.849
Wilks	1.866	2.2306	1.849
Physics: Pillais	0.03797	3.398*	4.3922**
Hotellings	0.03797	3.398*	4.3922**
Wilks	0.03797	3.398*	4.3922**
Chemistry: Pillais	1.629	3.6837*	5.386**
Hotellings	1.629	3.6837*	5.386**
Wilks	1.629	3.6837*	5.386**

* $P < .05$

** $P < .01$

Table (2)

Univariate F-tests Concerning Student Perceptions of Performance in Biology

	Effect:Teacher Sex F ratio	Effect:Stu. Sex F ratio	Effect:Teach. Sex X Stu.Sex F ratio
Difficulty of Course	1.07495	0.08696	0.0042
Performance Relative to Classmates	0.0003	0.00115	0.58895
Percentage of Time Understood Instructor	0.00592	0.02794	5.3793 •
Preparedness for Course	0.9462	0.02624	2.9853

• $P < 0.05$

Table (3)

Univariate F-tests Concerning Student Perceptions of Performance in Physics

	Effect:Teacher Sex F ratio	Effect:Stu. Sex F ratio	Effect:Teacher Sex X Stu. Sex F ratio
Difficulty of Course	7.3975**	1.9809	7.5658**
Performance Relative to Classmates	o.6470	4.7593*	2.0965
Percentage of Time Understood Instructor	0.6744	0.2172	6.4137**
Prepredness for Course	1.1976	1.3489	1.2559

* $P < 0.05$

** $P < 0.01$

Table (4)

Univariate F-tests Concerning Student Perceptions of Performance in Chemistry

	Effect:Teacher Sex F ratio	Effect:Stu. Sex F ratio	Effect:Teacher Sex X Stu. Sex F ratio
Difficulty of Course	4.68609*	1.24536	8.92696**
Performance Relative to Classmates	7.56041**	0.09283	8.62588**
Percentage of Time Understood Instructor	7.65166**	3.0555	5.49701*
Preparedness for Course	4.500*	0.18056	2.99015

* $P < 0.05$

** $P < 0.01$

ATTITUDE AND PERFORMANCE IN PHYSICS AND BIOLOGY OF STANDARD VI PRIMARY SCHOOL GIRLS IN KISII, MOMBASA AND NAIROBI DISTRICTS IN KENYA

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Summary

Kenyan girls are extremely underrepresented in physical science as compared with biological science studies. Very few girls elect physics in secondary school. Do girls elect biology instead of physics in secondary school because of attitude and performance differences in primary school?

Tests of attitude in biology, attitude in physics, biological science knowledge, physics knowledge, reasoning and knowledge of practical skills were administered to approximately 1200 Standard VI pupils in three districts in Kenya by M.E. Trowbridge and Dr. O.G.K. Tsuma. The mean values for girls and boys on all tests were compared for the total sample and for each district. Either there was no statistical difference between the mean values for the girls and boys or the difference was no more than a few percent. For the entire sample, the largest percent difference on a test was 3.3%

Six classes were observed in both physics and biology to determine whether the teaching environment was the same for boys and girls when the two subjects were taught by the same teacher. Classroom environment scores were given based on the number and type of interactions which occurred with the boys and girls. It was observed that when an average was taken over all classes, the girls and boys received nearly equal treatment in the biology classes but were given different treatment in the physical science classes. In the physical science classes the boys received nearly twice as much attention as did the girls.

Pearson-product moment coefficients were calculated for the entire sample with no correlation found between attitude and performance. A correlation coefficient of 0.94 was found between the classroom environment score for girls and the gap in biology attitude for boys and girls.

ATTITUDE AND PERFORMANCE IN PHYSICS AND BIOLOGY OF STANDARD VI PRIMARY SCHOOL GIRLS IN KISII, MOMBASA AND NAIROBI DISTRICTS IN KENYA

1. Introduction

Few Kenyan girls elect physics in the first cycle of secondary school (O-level). For example, in the KCE entries to the O-level exams in 1981, 22.1% boys, 4.9% girls chose physics 83.9% boys, 91.4% girls chose biology.(1) Girls attitudes toward physics are poor at O-level.(1) Those women who do not elect O-level physics are permanently barred from any further study of physics due to the educational structure in Kenya.(1,2) Because these choices are made at such an early age, it is important to know when and why in either primary school or early secondary school the difficulties arise. Is their performance in primary school higher than that in secondary school? If at some point in primary school their attitude and performance are good, that will lend support to the hypothesis that it is later discouragement which causes them to drop out.

The purpose of this study was to examine the attitude and performance in physics and biology of Standard VI primary girls in three districts in Kenya.

2. The Research

2.1 The Sample

The sample consisted of 400-500 Standard VI pupils from each of three districts in Kenya: Nairobi, Kisii and Mombasa. Mombasa and Nairobi are urban areas; Kisii is a rural area. The schools were public, co-educational schools. The classes examined had approximately equal numbers of boys and girls under one teacher. The distribution of examined schools was similar to the distribution of schools in a district. From 8-10 schools were visited in each district. The ages for girls had a mean value 12.7±1.4 years, for boys 13.1±1.6 years.

2.2 The Method

The method consisted of administering written tests to each pupil on attitude and performance. The attitude test was developed by Dr. O.G.K. Tsuma and consisted of twenty items, ten on biology and ten on physics. The performance test was developed by Ms. M.E. Trowbridge and consisted of 8 items on physics knowledge, 8 items on biology knowledge, 5 items on reasoning and 5 items on knowledge of practical skills.

Classroom observation was done is four schools in Mombasa and two schools in Nairobi by Ms. Trowbridge. The technique of *observation consisted of recording in each two minute time* interval the number of event points received by girls and boys. The event points were given as follows: 1 if the teacher called on a student, 2 if the student was called to the board or helped with a demonstration, 3 if the student was applauded (this occurred only once and was for a boy). -1 if the student was asked to erase the board (this occurred only once and was for a girl), -1 if the teacher reprimanded a pupil for answering incorrectly (if the student was called on, answered incorrectly and was not reprimanded he received a 1, if the student was called on, answered incorrectly and was reprimanded, he received a net score of zero, 1 for being called on plus -1 for being reprimanded). The event points were used to obtain the adjusted scores (AS) using two methods.

Method I consisted of totalling the event points for each sex in the class. In all cases the number of boys was not exactly equal to the number of girls. The absentee rate of the girls was higher. Therefore, the score for the girls was scaled upwards to correct for this. For example, if 20 boys received 30 event points and 10 girls received 10 event points in a class with the total number of pupils equal to 30, the event points for the girls were scaled upwards by 20/10 to 20 event points. The total adjusted event points are 30 plus 20 equals 50 and the AS for girls, $AS_G = (20/50) \times 100\% = 40\%$. The adjusted score for boys, $AS_B = 100\% - 40\% = 60\%$. The ratio $R = AS_B/AS_G = 60/40 = 1.5$ is the ratio of event points per boy to event points per girl. If R=1.5, on the average a boy received 1.5 event points for every 1 event point received by a girl. In a hypothetical class where the number of boys is exactly equal to the number of girls, the boys would have received 60% of the event points.

Method II consisted of totalling the event points for boys and girls within each two minute time interval. If the score for boys was greater than the score for girls, the boys received one point. If the score for girls was higher, the girls received one point. If the score was equal each sex received one-half point. The total score for each sex was the sum of these points, and gave the number of time intervals dominated by a sex. As in Method I the scores for girls were adjusted upwards to equalize the number of boys and girls. The AS_G was equal to the scaled score for girls divided by the sum of the scores expressed as a percent. That is, in a hypothetical class in which the number of boys is equal to the number of girls, the percent of the time intervals dominated by girls is AS_G.

2.3 The Results

2.31 Test Results for the Entire Sample

These results are given in Table I. The GAP is defined as the difference in mean values for boys and girls. The GAP in biological science knowledge was not statistically significant. The GAP in physics knowledge was 2.5% (girls lower) and was highly significant ($.01>P>.001$). The GAP in knowledge of practical skills was 2.4% (girls lower) and was barely significant ($.05>P>.01$). The reasoning GAP was zero. The GAP in attitude in biology was 3.4% (girls higher) and was highly significant. The GAP in attitude toward physics was not statistically significant.

2.32 Test Results for the Geographic Areas

These results are given in Table II. The results for the entire sample were the same for each geographical area in reasoning, attitude toward physics and knowledge of biology. There were some regional differences for the remaining tests. The GAPS for attitude toward biology were 6-7% (girls higher) in Mombasa and Kisii but 3% (girls lower) in Nairobi. The GAPS for knowledge of practical skills were 4-5% (girls lower) in Nairobi and Kisii but 0% in Mombasa. The GAPS for knowledge of physics were 3-4% (girls lower) in Mombasa and Nairobi but 0% in Kisii.

2.33 Classroom Observation Results

In the six observed classes when physics material was discussed $AS_G=(37.5\pm4.0)\%$, $AS_B=(62.5\pm4.0)\%$, $R=1.67$. For every one event point received by a girl 1.67 were received by a boy. A boy was 1.67 times as likely to be given attention in a class when physics material was discussed.

Table I
Test Results Entire Sample

variable		cases	mean	mean(%)		S.E.	T	df	GAP(%)
attitude in physics	boys	722	6.00	60.0	2.21	0.08	-1.5	1379	N.S.
	girls	659	6.18	61.8	2.18	0.09			
attitude in biology	boys	722	6.85	68.5	2.18	0.08	-2.99**	1379	+3.3%
	girls	659	7.18	71.8	1.96	0.08			
practical knowledge	boys	649	2.24	44.9	1.25	0.05	2.67*	1244	-2.4%
	girls	597	2.07	41.5	1.27	0.05			
biology knowledge	boys	649	4.78	59.7	1.65	0.07	1.37	1244	N.S.
	girls	597	4.65	58.1	1.57	0.06			
physics knowledge	boys	649	3.52	44.3	1.64	0.06	3.03**	1244	-2.5%
	girls	597	3.24	40.5	1.55	0.06			
reasoning	boys	649	1.71	34.3	1.16	0.05	-0.00	1244	0.0%
	girls	597	1.72	34.3	1.13	0.05			

* barely significant (.05> P> .01) ** highly significant (.01> P> .001)

N.S. = not significant

Table II
Test Results Each Geographic Area

		cases	mean	S.E.	GAP	cases	mean	S.E.	GAP	cases	mean	S.E.	GAP
attitude physics	boy	215	6.145	0.131	N.S.	245	5.874	0.126	N.S.	244	6.082	0.168	N.S.
	girl	205	6.195	0.130		211	5.962	0.137		219	6.384	0.174	
attitude biology	boy	215	6.642	0.135	6.4%	245	6.994	[illegible]	-3.0%	244	6.971	0.161	6.6%
	girl	205	7.251	0.121		211	6.802	[illegible]		219	7.648	0.157	
pract. knowledge	boy	193	3.551	0.086	N.S.	244	2.418	0.218	-4.8%	212	2.860	0.076	-1.8%
	girl	198	3.576	0.077		204	2.176	0.386		155	2.472	0.073	
biology knowledge	boy	193	4.117	0.121	N.S.	244	4.902	[illegible]	N.S.	212	5.198	0.121	N.S.
	girl	198	4.266	0.104		204	4.841	[illegible]		155	4.836	0.114	
physics knowledge	boy	193	[illegible]	[illegible]	[illegible]	244	[illegible]	[illegible]	[illegible]	212	[illegible]	[illegible]	N.S.
	girl	198	[illegible]	[illegible]		204	[illegible]	[illegible]		155	[illegible]	[illegible]	
reasoning	boy	193	1.745	0.081	[illegible]	244	[illegible]	[illegible]	[illegible]	[illegible]	2.427	[illegible]	N.S.
	girl	198	[illegible]	[illegible]		204	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	

[illegible] [illegible] [illegible]

N.S. : difference in mean values less than the sum of the standard errors.

In the same six classes when biology material was discussed by the same six teachers AS_G=(54.7±4.2)%, AS_B=(45.3±4.2)%, R=0.83. For each event point received by a girl, 0.83 event points were received by a boy. Girls were given slightly more attention when biological material was discussed.

Using Method II which gives the percent of time dedicated to attention giving which is dominated by each sex, the results were AS_G=(32.0±7.2)%, AS_B=(68.0±7.2)%, R=2.1. The results for biology were AS_G=(50.6±3.7)%, AS_B=(49.4±3.7)%, R=1.0. The results for Methods I and II are extremely similar.

Four of the teachers were male and two were female. Using Method I, under the male teachers, in physics R=2.17 and in biology R=0.73. That is, in physics the boys received 2.17 event points for every one event point received by a girl. In biology the boys received 0.73 event points for every one event point received by a girl. Under the female teachers there was no statistical difference in the scores for boys and girls in the two subjects.

2.34 Correlations

Calculation of the Pearson-product moment correlation coefficient did not show any correlation between attitude and performance.

Correlations:Girls

	AP	AB	PR	B	P	R
AP	1	0,5180				0,0282
AB	0,5180	1		0,0915		
PR			1	0,2678	0,2707	
B		0,0915	0.2678	1	0.3694	0.1920
P	0,0282		0,2707	0.3694	1	0,2398
R				0.1920	0,2398	1

AP attitude in physics
AB attitude in biology
PR practical knowledge
B biology knowledge
P physics knowledge
R reasoning

Boys

	AP	AB	PR	B	P	R
AP	1	0,5220			0,0315	
AB	0,5220	1		0,0869		
PR			1	0,3171	0,2470	
B		0,0869	0,3171	1	0,3192	0,1980
P	0,0315		0,2470	0,3192	1	0,3028
R				0,1980	0,3028	1

For the observed classes the mean values for the written tests for boys and girls were not significantly different except for the attitude toward biology. A correlation between AS_G and the GAP in the attitude toward biology was found to be 0.74 for Method I and 0.94 for Method II.

3. Conclusion

Assuming that this data is representative of the girls in Kenya, we may conclude that women in Kenya do not choose biology over physics because of attitude and performance differences at the Standard VI level (mean age 13 years). While differences exist for the different tests and the results show some regional variation, the differences are small in all cases.

Although the classroom observation data was limited, it supports the existence of discrimination against girls in physics by some teachers and the absence of that discrimination in biology.

The lack of correlation between attitude and performance was not anticipated and may be the subject of further investigation.

4. Acknowledgement

I would like to thank Dr. O.G.K. Tsuma for collecting the test data for half of the sample, for developing the attitude instrument and for considerable assistance in the computer formatting and analysis of the data.

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SOME PROPOSALS FOR INTEGRATION OF AFFECTIVE AND COGNITIVE ASPECTS IN PHYSICS EDUCATION

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ABSTRACT

A multidimensional strategy is needed to make the physics education less sexpolarizing. In this paper I will focus on the possibility of integrating the affective and cognitive aspects in physics education. I will describe some methods of teaching that we have used to integrate intellect and feeling in the learning situation. We think that this integration is essential to get more girls interested in learning physics and at the same time it will increase the learning-quality of most of the boys.

INTRODUCTION

This article will be based on the results of my ongoing work in cooperation with Karin Beyer, Sussanne Blegaa and Jette Reich in the research project: "Sex-roles and physics education - an analysis of the sexpolarizing effect of the subject." We are teachers of mathematics and physics, and the project deals with pupils in the Danish Gymnasium (upper secondary school, age 16-19).

In another contribution to the conference (1) the project is described in further detail.

INTEGRATION OF THE AFFECTIVE AND COGNITIVE ASPECTS IN EDUCATION

An integration of intellect and feeling seems to be necessary for experiencing the meaningfullness of schoolwork as well as obtaining real learning. The more you experience that a case concerns yourself the more it will influence your beeing and your actions. Through our way of teaching the pupils must learn to make this integration of the affective and cognitive factors.

We have tried to solve this problem in different ways. In the following we will treat the influence of

1) the teacher's organization of "the climate of teaching",
2) making the pupils aware of their feelings in connection with

learning and 3) our attempt to make a confluent approach to a theme in physics.

THE CLIMATE OF TEACHING

Learning new things requires a certain personal courage, self-confidence and willingness to take a risk. In different ways we have tried to improve the climate of teaching to increase the pupils' feeling of secureness in the learning situation, so that they dare expose themselves to new conceptions.

The topics in physics can never be person oriented, which means that the subject and the physics teacher will often be regarded as cold. Often teachers dealing with other subjects also regard physics teachers as cold and narrow-minded experts. Therefore it is necessary to try to change the general feelings associated with physics.

The physics teaching-rooms are often equipped without any consideration for making them cheerful and esthetic, so we have tried to make the rooms more cosy with colours, pictures and flowers.

As mentioned above, it is not evident through the topics in physics to open up for spontaneous talks about personal and social problems, therefore we have tried to let the physics teachers make cheerful meetings in the afternoon at the school with the pupils or let the teacher invite the pupils home, so that they see the teacher in more well-known familiar surroundings.

The pupils tell us that it does matter a lot for their feeling of secureness in the physics lessons that they know the teacher from other and more personal situations.

In the class-room during the teaching it is a good idea once in a while to make tea for the pupils. If the teaching hours are late in the afternoon it is often difficult for the pupils to concentrate on learning. It is then a good idea to begin the lesson by letting the pupils sit down, relax and without talking together - if convenient with their eyes closed - listen to relaxing music.

We have had success in using this approach.

MAKING THE PUPILS AWARE OF THEIR FEELINGS IN CONNECTION WITH LEARNING

We teach the pupils how to keep a record of their feelings and thoughts - both the positive and the negative - by making notes about what they feel every time they meet a new formula/topic/experiment etc. That means that "they have themselves with them" in everything they are learning.
We have seen methods similar to our own in an article (3) by Sheila Tobias (1985), who is especially occupied with math anxiety, and in a book (4) by J.V.Mallow (1986), who is occupied with science anxiety. Another way to make the pupils attentive and to motivate them is to let them give their evaluation of every theme they have been through, both a written and an oral evaluation.
First they have to make a written evaluation of the theme, because then the pupils - even the silent girls - will get an opportunity to think out the answers before the oral evaluation.

The girls are much more careful in their reply to the evaluation-questionnaire than the boys. And it seems more essential for the girls than for the boys to get an opportunity to evaluate every theme. Of course it is highly important that the pupils in the next theme will be able to feel that the teacher has paid regard to their criticism of the former theme.
It is essential that we teach the pupils that the road to learn something can be associated with a strong touch of disinclination, while it will be delightful, when something new is properly understood. Once you have come unhurt through a difficult learning situation, it is much easier the next time.
A girl told us:

> *"In the beginning all the formulae*
> *swam in my head, but then suddenly*
> *I understood it all, and I became very*
> *happy, and I wanted immediately to learn*
> *something new."*

A CONFLUENT APPROACH TO A THEME IN PHYSICS

Confluent pedagogy is based on "gestalt-therapy". It came from California (in the late sixties), but we became acquainted with it through the book (5) (in Norwegian) "To learn is to discover", written by Nils Magnar Grendstad (1982).

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Confluent education means an education where you try to let the affective and the cognitive aspects in the learning flow against the same goal. But to make this possible it is necessary to teach the pupils to be aware of their feelings, when they are working with a certain topic.

Science of electricity is a subject which particularly puts off the girls, because it has a masculine image. Therefore we have tried a confluent approach to this topic.

We wanted hereby to remove the girls' built-in anxiety and alienation.

Later we have successfully used the same kind of approach on themes about energy, waves, and light.

The introduction lasts about two lessons, and it may be carried out in the following way: In the beginning we play some music, which can give associations to the theme we are going to treat. When the music is on, the pupils have to sit down relaxed and without talking together, concentrating on the music. To obtain maximum concentration it is most expedient if the pupils' eyes are closed. After the music has finished, the pupils are going to write down their individual experiences about the topic. We stress that they must especially write down their every-day experiences.

The purpose is that we want the pupils to etablish a connection between the conceptions of every-day-life and the scientific concepts which they have to learn in school. Very often the conceptions of every-day-life and the scientific concepts exist side by side without any connection. As a consequence the pupils don't really understand the scientific concepts, and therefore they can only use them in very specific situations.

In addition to the above mentioned purpose, we want to etablish a relaxed atmosphere as an introduction to the theme and to show the pupils that actually they have already had some valuable experiences about the subject. For instance all the girls have had experiences with static electricity and electric shocks, even though they haven't played with electronics.

After that the pupils have separately written down their experiences, they discuss in small groups what they have experienced, and must together give their definition of electrical current. The answers from the groups are then discussed in the whole class. The result of this discussion is used as a starting point for teaching about electrical currents.

Through sequences like the above mentioned the girls feel that their experiences are relevant, even though they are not nessesarily the same as those of the boys.

If a concept is going to get a meaning for a person, it is important to interpret the concept in as many ways as possible. It is important to "walk around the concept and look at it from all angles", i.e. to expand the meaning of the concept - this will also be obtained by using the confluent approach.

We have had success in using the method. The pupils were obviously more motivated for learning about the topics which were introduced in a confluent way.

One of us has tried to use a confluent introduction to a course in electrical science for an entirely different group of "pupils", namely a group of long-term-unemployed women aged from 26 to 54. They were going to have introduction courses to the semi-skilled workerschool in the electronics.

The group was extreme in several respects, because the participants were very motivated to learn about electricity, and because their school-background was very poor. Even trough in advance a lot of the participants were very anxious about physics, the course became a success. The main reason was that the experiences of the participants were stressed as being important, and another thing was the good personal relations between the participants and the teacher.

FURTHER PERSPECTIVES

We are working on how to get the confluent pedagogy to influence the whole education more. For instance, in order to use the pupils' every-day-experiences, we have used another section in electrical science, which we call: "I also use electricity". In this section the starting-point is taken in the use of electricity in the private homes.

The pupils were told to read their electrical-meter at home every morning and evening for fourteen days. After that the pupils worked in small groups, where they had to compare and explain their expenditure. This section engaged a lot of girls, and some of them started to consider if they should change some of their habits to decrease their electricity-expenditure.

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To get more girls learning physics it is not sufficient to change the curriculum and the teachingstyle if the affective aspects are not integrated.
The above mentioned proposals to integrate the affective aspects in learning physics are exemples and are not to be understood as complete recipes, but as something we must get on with.

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More girls to technical jobs - an action plan

Anita Ferm

Teh Swedish National Board of Education

In the fall of 1986, the Swedish National Board of Education was planning an information campaign concerning expected future changes in the labour market. The campaign was aimed at, not only school girls, but the whole population of Sweden. The intention was to do a joint effort together with trade and industry.

We know that practically all occupations become more and more technology dependent. We also know that boys spread out over more than 300 different jobs, while girls choose between only 50 different occupations, the majority of which are found among office, trade and nursing works.

It is very difficult to make girls choose a technically oriented job.

In Sweden we have interviewed a group of 15-year old girls, asking who it was that had the strongest influence on their choice of education in upper secondary school. Almost in every case the answer was, "the parents".

It appears as if Swedish parents are hesitant to accept that their daughters choose a technical education and technical jobs. This means that a campaign attempting to get more girls to choose technical professions also must be able to convey, to the parents, information on tomorrow's labour market.

Futhermore, we have to consider that also the traditional "women's jobs" will get more and more technical. Regard e g the occupation in medical

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services where the equipment used steadily is getting more and more complicated.

The purpose of the campaign planned was to inform - and thus to increase the awareness of - everyone involwed (teachers, students, parents, politicians, schoolprincipals and all people in the labour market).

We would attempt to tear down prejudices about women and technique, thus changing the working conditions. We need more girls in industry and we need to make them comfortable and to stay.

The start of the campaign was intended to be an exibition with the motto "Now is time to create the future". Each region should have their own exhibition, running in parallell with all other regions.

The exhibitions should deal with the following issues. 1. Tomorrow's labour market. 2. School and education. 3. Girls' jobs - boys' jobs. 4. Developments in ones own region. The contents of the three first items should be similar throughout the whole country.

We intended to produce a TV movie to show in schools, places of work etc.

A video tape and a newspaper on "girls' jobs - boys' jobs" should be produced for the students. They were to be promoted by trailers showed at the ordinary movie theatres.

Short TV spots were to convey information to the parents. Meetings with the parents were to be organized in schools.

In order to infuence the teachers a pamphlet should be produced pointing out prejudices and "oppressive behaviour" from the teachers themselves. Special seminars were to be arranged in order to improve the equality in the class-room.

The news media were to be continously informed about on-going activities.

The intention was that also the labour market should work with these questions in the places of work.

The whole campaign was planned to last for at least three years costing about 1 million US dollars.

We believe that such a broad approach is needed in order to change, in any major way, the present very unsatisfactory situation.

Unfortunately, the labour market has been interested, but not enough to provide any funds for the campaign. This means that the Swedish Board of Education at present has had to considerably lower the level of ambition for the campaign. It has e g not been possible to carry out the exhibitions described.

The production of a 30 min movie has, however, started. This film will discuss:

- what children and young people expect of the future

- the promises from the politicians and how they have turned out in reality

- facts about the labour market, the shortage of technically educated people etc.
- what students, parents and teachers think about today's education
- what are the conditions today for a woman in a technical job, and how would she like them to be
- what a positive vision of the future would look like.

About a year ago an investigation was carried out asking girls with high marks in mathematics and natural science subjects, why they had not chosen to continue with a technical or natural science education in upper secondary school. Typical answers were:

- Mathematics and physics are boring
- Our teacher says that girls cannot manage natural science subjects
- I will have to work much less if I choose languages or social sciences.

When girls actually studying natural sciences were asked to describe their situation, they wrote:

- Physics has no connection to every-day life
- Biology and chemistry is fun because there is a relation to man
- It is difficult to see what physics is good for.

Also about a year ago a Norwegian report was published discussing Norwegian text-books in physics, used in compulsory school or in upper secondary school. The report stated clearly that these text-books were written entirely for boys.

When we made a similar study of Swedish text-books in physics and in technology, we found a similar situation. The majority of the books are written by men. The language and the examples mirrors the world of boys and men. Very few examples are taken from the female every-day experience. We also know that the teachers from the very first day in school, pay boys more attention than girls. Against this background it is only natural that girls feel unfamiliar to physics. We also have reasons to believe that the situation is the same at the university level.

The Swedish part of the IEA investigation has recently been completed. Pupils in grades 7, 8 and 9 were tested for their abilities in natural science subjects. The results show that boys achieve better results than girls in all subjects. The differences are fairly small in chemistry and biology and noticeably big in physics.

An ad hoc working group is presently carefully assessing each individual question in the tests. Preliminary results indicate that the major difficulty for the girls was caused by questions requiring a "spatial" ability. Our definition of "spatial" has been "the ability to transform a text or a figure into a course of events". This type of question is particularly common in physics when e g studying electricity or mechanics. The next step in our work will be to try to change the language used and the exemples selected in the text-books as well as the didactics in these subjects.

A promising development can already be seen in many schools. It is getting increasingly common that each new part of the subject starts with a discussion, in the class-room, abour a familiar phenomenon.

From this basis the scientific laws and equations needed are developed. In this way we hope we will be more able to create more equal conditions for the girls.

PSYCHOLOGICAL TYPE AND SCIENCE CAREER

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Abstract

It is likely that an increase in the proportion of professional scientists who are women will bring about profound changes in the science community, in both the issues it addresses and the way it works. For example, female scientists might employ different cognitive styles from their male counterparts. The main difficulty in exploring that hypothesis is that the literature relating to cognitive styles is so confused, with respect both to the constructs and the empirical procedures.

The author made an indirect attack on this issue by employing the Myers-Briggs Type Indicator test for psychological type with student groups. That instrument assesses something very akin to cognitive style. Preliminary findings have been most promising with clear discrimination being found between sub-groups, female scientists, male scientists, etc. From these findings it is possible to generate a more complete description of members of each sub-group which, in turn, illuminates the likely underlying psychodynamics.

Introduction

Only a decade ago the primary concern of those interested in issues of girls and science was simply in the lack of girls opting for science careers. That lack was seen to deny women access to important and remunerative careers and to deny our societies the benefits of many potentially able scientists. The battle to redress the balance has clearly been won, albeit the effects may not yet be fully manifest.

Publishers are now sensitive to the possible sexist character of science textbooks. Teachers, schools and employing authorities have become aware of the situation. The curriculum is being examined to see if more girl-friendly science can be introduced.

We can now move on to ask what effect will the increase in proportion of women in science have on the science community. That question touches on the underlying issue whether there are fundamental psychological differences between the sexes. Does equality mean identity, or equal but different? The current trend in psychology is to recognise that within the equality lies diversity, and that diversity is a source of strength. It gives us the wide range of skills, abilities and beliefs to respond flexibly to circumstances.

Cognitive Styles

An important example of such diversity is that of different cognitive styles. Traditionally we have been concerned in cognitive psychology with performance measured on a linear scale e.g. I.Q. and most school tests, and little attention has been given to the existence of viable and legitimate alternative approaches to a problem.

At least four lines of evidence suggest that women scientists possess characteristically different cognitive styles from their male counterparts:

1) The direct evidence from cognitive style research literature in which gender differences are reported (e.g. Kogan, 1976)
2) The biographical evidence about women scientists (e.g. Keller, 1983)
3) The evidence that male and female science students possess different personality characteristics which are likely to generate different cognitive styles (Head, 1980 and 1985)
4) The theoretical models of human development e.g. Harding (1985) on object relations and Head (1983) on identity development, which imply gender differences in cognitive style.

From these four lines of evidence we can anticipate that female scientists will differ from their male counterparts in various ways, e.g. in being more holistic or global in their thinking.

Problems with Cognitive Style Research

It is at this stage that some major problems become manifest. The actual constructs have been poorly conceptualised. Messick (1976) lists over twenty descriptions of cognitive styles, yet I doubt if we can actually distinguish more than about five or six. We might, for example, suspect that field-dependence, global thinking, holistic thinking and relational thinking mean much the same thing. In that event we may wonder just how much overlap there is between these four constructs, what are the differences, and which is the clearest measure of the underlying common factor.

Further difficulties can be illustrated by looking at Witkin's classic work on field-dependence e.g. Witkin and Goodenough (1981). The construct has been conceptualised more as an ability, that of field-independence, which people may or may not possess, than a style with a valid alternative. One has to search the literature with diligence to discover that in open-ended situations field [illegible] is an advantage. As females tend to be more field-dependent they are underestimated. We might object, too, to the test employed in this context which demands analysis of a visual stimulus (embedded figure). Females are again disadvantaged. Complementary test items, involving verbal as well as visual, relating as well as analysing, are needed to yield a fair test of the alternatives.

Use of the Myers-Briggs Type Indicator

In the event the author opted for an indirect exploration of cognitive style differences by using the M.B.T.I. This is a well-established and validated test instrument widely used in vocational guidance and counselling. It identifies the habitual types of responses made by an individual to the outside world and other people - something very akin to cognitive style.

The underlying theory can only be described in outline here. Based on Jung's (1923) description of psychological type, it describes people in terms of four bi-polar parameters. The immediate problem is most of us find it difficult to think in terms of four dimensional space, and often prefer to take two parameters at a time for consideration.

The next problem is that of terminology. One parameter has a pole labelled as 'Sensing'. It is not obvious what the term means. The translation is sometimes given as 'sensation' which is even further from the construct, that of relying on primary sensory inputs. Both Bacon in his advocacy of inductive methods and behaviourist psychologists argued for the benefits of the sensing style. We must ignore everyday meanings to the labels and recognise them as technical terms in the test context.

The four parameters are:

Extraversion-Introversion (E-I) as these are technical terms in the first instance, they present little confusion

Judgement-Perception (J-P) whether the outside world tends to be just perceived or evaluated

Sensing-Intuition (S-N) whether perception comes only from primary sensory inputs or whether one tries to imagine what might be there

Thinking-Feeling (T-F) whether judgements are arrived at through predominantly cognitive processes or whether feelings are accepted.

Various combinations of these qualities are associated with success in different careers. For example, Myers (1962) suggested that academic scientists, probably predominantly male, were intuitive thinkers. The intuitive quality marked their interest in what was not yet known, the possibilities which might be imagined, while the thinking pole indicated a preference for seeking answers through cognition. In contrast, academic humanists tend to be intuitive feelers, sharing the concern with possibilities, but guided more by feelings in making judgements. Further details of links between the Myers-Briggs types and science will be discussed later.

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Pilot Study

At the time of writing, the results of a pilot study with 124 able British school students aged 16 and 17 are now available. After the age of sixteen in Britain students cease to follow a broad curriculum and have to specialise in about three school subjects, therefore at that stage we can label the students as scientists or arts students according to that choice. Of the 124 students tested, eleven had subject choices which did not allow such labelling to occur and their responses were not included in the analysis. The remaining 113 students were identified as 25 male artists (MA), 25 male scientists (MS), 31 female scientists (FS) and 32 female artists (FA).

The full results are shown in Table 1.

	ESTJ	ESTP	ESFJ	ESFP
FS	6	3	3	1
FA	0	1	1	1
MS	1	2	0	4
MA	1	2	1	1

	ISTJ	ISTP	ISFJ	ISFP
FS	6	1	3	0
FA	1	1	1	0
MS	7	0	0	2
MA	4	0	1	0

	ENTJ	ENTP	ENFJ	ENFP
FS	2	1	2	7
FA	2	3	2	6
MS	1	4	0	0
MA	1	6	3	1

	INTJ	INTP	INFJ	INFP
FS	0	2	0	2
FA	5	5	0	4
MS	4	4	3	1
MA	[illegible]	1	2	3

Discussion

Laid out in that extended form it may prove difficult to see the significant features of the data, so a few points will be highlighted. Four statistically significant differences, using the chi-squared test, between sub-groups can be reported:

1. On the S-N scale, female scientists were more S than N and male scientists were more N than S (at a 5% level of significance)
2. On the J-P scale, female scientists were more J than P and male scientists were more P than J (5%)
3. On the S-N scale, female scientists were more S than N and female artists more N than S (1%)
4. On the J-P scale, female scientists were more J than P and female

artists more P than J (1%)

Are the scientists NT types as Myers (1962) predicted? Eleven of the 25 male scientists fell into that quartile, giving confirmation to the prediction, but only five of the 31 female scientists were in that sub-group. That confirms the belief that Myers norms for scientists only apply to male scientists.

What about the prediction that the humanists would be NF types? Eleven of the female artists and nine of the male artists fell in that quartile, which again tends to confirm the prediction.

Perhaps the crucial question is to ask whether the female scientists were a distinctive group. The results are striking. Nofewer than eighteen of the 31 female scientists were in the SJ quartile. That result is most important as hitherto we have had full descriptions of the characteristics of male scientists, that of being conservative, emotionally reticent etc. (see Head, 1979 and 1985) but have lacked an adequate psychometric description of their female counterparts. These findings allow us to begin filling that gap in our knowledge.

What are the characteristics of SJ persons? Myers (1962) suggested that J types work best when they can plan their work and follow that plan. They like to finish tasks without interruption and may not notice new things to be done. The S types like established ways of doing things, are patient with routine details, work in a stepwise fashion, are precise and seldom make errors of fact. Can you recognise your female science students in these descriptions? It must be noted at this stage that I have reduced a complex description to a few lines and may not have done justice to it in the process. None of these paired characteristics is in itself better than its partner, and both types of people are needed in our community to fulfil the variety of roles which humans have to carry out.

Mitroff (1974) used Jung's typology to describe four types of male scientists which he identified in his work - the Hard Experimentalist (S pole dominant), the Abstract Theorizer (T dominant), the Intuitive Synthesizer (N dominant) and the Humanist Scientist (F dominant). It is not clear whether a parallel typology can be applied to female scientists. The lack of female Humanist Scientists, with the F pole dominant, among the school population may cause surprise, but that would be a test artefact as the norms for males and females are different on the T-F scale. What can be gained from Mitroff's work is an alternative methodology, that of supplying a biographical description of types of scientists and asking respondents to state which was closest to themselves.

The findings from the pilot study proved promising in identifying female scientists as a distinct group and thus allowing us to describe their characteristics. A study of a much larger population of school students in the 16-18 year old range is now being conducted to check these preliminary findings. Further work envisaged includes asking a few adult creative scientists to complete the MBTI in order to distinguish between that select group and the main bulk of science students at school and college level. The sorting out of the variety of types contributing to the functioning of science is a complex task but we are beginning to recognise the diversity of talents different people can bring to their work, and that diversity confers potential flexibility to the science community. We should certainly celebrate the existence of such diversity.

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LABOUR MARKET DIVISION IN SWEDEN AND ITS EFFECTS ON ATTITUDES AND EDUCATION

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Summary:

An extremely clear sex-dependent labour market division was found in a recent study of the conditions of women in education and labour market in one region in Sweden, Norrbotten. Similar studies have been carried out at the request of the Ministry of Labour in all regions in Sweden in 1985 - 86. These studies have since been the starting point of programs introduced in education and on the labour market during last year.

This paper draws the attention to the causes of this divided labour market and to its profound effects. Some suggestions are made on how to achieve a change in the situation. Long-term programs involving not only young girls, but also parents, teachers etc are here seen as more efficient than encouragement strategies for young girls only. Legislation is generally assumed to be the most important prerequisite to achieve equality. The labour market division in Sweden shows that other circumstances are even more important.

The situation in education and labour market and the effects of different strategies have been carefully examined and studied over the last ten years. This knowledge must now be put to use by politicians and other decision makers to form the equal society of the future.

1 Introduction

The majority of the industrialized countries in the west and in the east are facing the same problem of underrepresentation of women in the science and technology sectors of education and working life. Sweden is no exception, even if the country has no doubt reached further towards equal conditions for men and women in society than many other countries.

The question of women's participation in the technical sector of the labour market has in recent years also grown to be a concern of the industrialists - not only of the women's rights workers. The reason for this is of course primarily the present demand for skilled and educated technicians at all levels of industrial work, and the future prospective involving not only the male part of the population at large in the industrial development but also a much larger proportion of the women.

2 Recent strategies

The struggle for real equality in recent years has thus in Sweden been focused on increasing the participation of women in the fields of science and technology, both in education and in the labour market in general. The so-called 10 Million campaign, initiated by the Ministry of Labour four years ago, brought the issues of women and technology to the attention of almost every Swedish citizen. Many projects were then organized and carried out with the aim of making more girls choose careers in science and technology and also taking good care of those who really did.

Even before that, various institutions, like e g the Luleå and the Linköping Universities, the Royal Institute of Technology in Stockholm, and others, had been working more or less consistently and partly successfully towards the same goal. At the Luleå University, the proportion of female students among those starting an engineering education went up from a modest 9 per cent in 1979 to an all-time-high for Sweden of almost 30 per cent in 1983 as a result of encouragement programs staged by the University. The Luleå University still has the lead nationwide, reaching 28 per cent in 1986 after a temporary drop to slightly below 25 per cent in the years 1984 and 1985.

The programs so far carried out in Sweden have included several different strategies. There is still much done - and should be - to encourage and change the attitudes of girls in different age groups. School programs are developed, with special care to make girls feel more at home with science and technology. Girls' career programs are introduced into the school curriculum by teachers and counsellors. Costly efforts have been made by the National Swedish Board of Education to give elementary school teachers in-service training in science and technology.

Other strategies again have focused on the problem of adjusting the school system to the labour market. This was the aim of many of the programs initiated after surveys made by the regional authorities all over Sweden at the request of the Ministry of Labour. These surveys made it all too clear that the labour market in Sweden is still a divided one, and will remain so for years to come if no drastic action is taken to change the conditions for women in working life and education.

3 The Norrbotten case - an example

The survey made by the regional authority in the northernmost region (or county; Sw. "län") of Sweden, Norrbotten (1) (2), offers in many ways a good example of how labour market conditions affect other parts of society, above all the educational system, and thus also conserve attitudes and behaviour among the population.

A brief description of the region of Norrbotten will be needed as a background. Norrbotten is sparsely populated, except for the regions along the coast of the Gulf of Bothnia and the mining cities in the inland mountains. The population totals 265 000 approximately. The region is rich in natural resources - iron ore, timber and hydroelectric energy. The economy relies heavily on industrial production. Luleå is the capital of the region, the biggest city with a population of about 70 000 and the center of administration and education, including the Luleå University.

The statistical part of the survey (1) shows women and men in the region to be found in almost completely separated labour market sectors. The labour market for women is narrow. As much as 82 per cent of the working women in Norrbotten are found in only three branches of the economy: the public sector, including health care, private service enterprise, and trade. In other words, women tend to devote themselves to a kind of public equivalent to women's domestic roles of yesterday. The male sector is dominated by heavy industry: steel processing, mining, and timber industry, especially paper and pulp industry.

The percentage of women working outside the home is rather high in the ages between 25 and 44 years of age, 72 per cent, but still lower than the average for the whole country, which is 77 per cent.

Economic depressions striking at the above mentioned industrial branches have been fatal to employment generally. Young people and women have been more exposed to unemployment, and unemployment among women will undoubtedly be still more common as the public sector contracts, being subject to reductions in public spending.

There is no lack of options for young people in the region as far as education is concerned and there are many different study programs in the science and technology sector of education. These programs include theoretical education preparing for university studies, vocational training at different levels, ranging from shorter practical courses to more advanced technical studies, and engineering education at university level. The scope of educational possibilities is wide, and although some students will have to leave the region to pursue studies they wish to devote themselves to, there is also a fair number of students coming to the region to specialize in educational fields which do not exist in their own regions or even elsewhere in the country.

The distribution of female and male students in the educational system is nothing but a reflection of the labour market situation. Male students are predominant in all technology-oriented study programs, whereas female students make up 75 per cent of the students in humanities and social sciences at senior high school level (Sw."gymnasium"). The somewhat brighter but still unsatisfactory situation in the engineering education at the Luleå University has already been mentioned.

So, despite all that has been done and is still is being done to encourage a non-traditional choice of education and career among young girls, and despite the unemployment in the traditionally female vocational fields, the basic attitudes of the young people of Norrbotten and of their teachers and parents are still relatively unchanged. What are the reasons for this, and how could the situation be changed?

4 Reality speaks for itself

There is no doubt that the division of the labour market means very much to young people planning their future. Some rather few students may have special talents and interests that will help them to persevere in choosing untraditionally. Others - the majority - are inclined to do what others have done before them. The divided labour market is a reality that young people in Norrbotten are facing every day. Mothers do "women' s work" and fathers do "men's" - this is their personal experience, and it affects their thinking and career planning profoundly. School programs to overcome the sex barriers in education do not easily convince a young person that she (or he) should take the trouble of pioneering into non-traditional education and careers. Young people will rather choose their education according to tradition, even if it means that they will have less chances to get a job in the future.

This may seem to contradict the assumption that labour market conditions are important to the choice of education. But young people are often strongly influenced by an older generation of parents and teachers, who are not aware of the profound changes that have started to affect and will go on affecting working life.

Also, those who have ventured to become pioneers, be it in education or in working life, have in many cases experienced difficulties, being treated in a discriminating way, in class by teachers and fellow students and in working life by colleagues and superiors. Women have also had difficulties in getting a job that would match their qualifications after finishing their training, whereas the men as a rule are employed more quickly. This was shown in a small study (3) made in another industrial city (Sundsvall), situated further south in Sweden.

Here, out of 31 female students having completed shorter vocational training in 1983 - 85, only 4 got jobs they were trained for. Male students, on the contrary, were offered jobs right at the end of the training, and appropriate ones. Such facts will of course automatically lead to a set-back for the untraditional choices in education, as rumours spread.

Reality will continue to speak for itself, and this will be fatal to the struggle for equality. One cannot expect a breakthrough for girls in science and technology as a result of the encouragement strategies applied. It is time to see what can be done about the reality that contradicts these efforts.

5 Some suggestions for education

A change in our diverse reality can of course only be achieved by applying diverse methods varying from setting to setting. The following suggestions may be applicable to the European/Scandinavian situation in particular.

The planning and building of science centers, which has started just recently in Europe and in Sweden, offers many chances to overcome the barrier of technology for girls at an early age, and also to create a climate where boys and girls can play with and learn to understand technology together. Judging from the way science and technology centers are functioning e g in the United States, this should be one way of working on attitudes among children and adults simultaneously. Attitudes of girls towards technology and of boys towards girls in technology are formed very early. No doubt the influence of the parents must even in many cases be actively counteracted. Some other parents may need support for a non-traditional view of sex-roles and will be able to get that support through the activities in a science center which is planned and run with an eye to the situation of women in technology. Also, a science center that pays attention to these issues will be of great help to teachers and schools wishing to work more intensely on equality problems and to create a more girl-friendly science and technology. There is hope that a new generation in this way may become less sex stereotyped and less inclined to carry on the division of labour displayed today.

The role of the parents has recently been in focus in Sweden. Results of an enquiry presented at a conference for school leaders, counsellors and teachers in September 1986 showed that parents were the most influential group consulted by young people in matters of career and education. Friends and classmates were next, before teachers and counsellors (!).

Counselling and study guidance has often been considered crucial. However, the teacher seems to be a much more important person, considering the amount of time spent with the children and the close relationship between the children and the teacher, especially in the lower grades. The double role of the teacher, as a role model and a bearer of attitudes which are transferred to the children from the earliest ages, must be taken into account and treated more profoundly in the teacher's training. The problems of the classroom situation have been very convincingly demonstrated by research that has been accounted for in earlier GASAT conferences. In consequence, politicians and planning authorities must be convinced that measures be taken to improve the teachers' training and teachers' in-service training. The EQUALS concept developed in the United States would be of great help, if it could be transferred and "translated" into European teacher's training.

The need for a girl-friendly science and technology has to affect the contents of the science and technology education more profoundly. Text books must be reviewed and criticized, and a more holistic view of the role of women in technology and technology in society must be introduced. Female teachers and scientists must be involved in this work.

The Swedish school system has been co-educational for a long time, and hardly anyone in Sweden would like to change that. (Which should not - on the other hand - prevent the creating of special girls' classes in science and technology, if needed to give girls more confidence in themselves.) At present, however, there is a tendency in Sweden to encourage the splitting up of the educational system into sectors corresponding to labour market sectors. Local planning authorities are already - for practical and economic reasons - dividing education into schools of science and technology and schools of humanities and social sciences. Considering the distribution of female and male students in the different fields, this also means that education is getting more and more segregated. If this tendency is allowed to break through, the gap between the sexes will be much more difficult still to overcome at all levels.

Finally, it is the responsibility of all researchers to clearly convey to the decision-makers all the facts and the knowledge collected during the years. To bring about change not only knowledge but power is required. The demands of industry for more and better educated technicians and the national needs to strengthen technology all over the world must be used to work for women - not against. The present focusing of the environmental problems can only underline the urgency of the case.

6 Labour market sharing - not division

The demand for technically skilled labour must obviously be taken as a challenge and a chance by women all over the world. In industry, many women have been employed in jobs where no technical skill has been needed. The computerization may counteract this - and the traditional job division so clearly demonstrated in the Norrbotten case - but only if women accept this challenge. We can no longer take a negative stand on computers - they are there to stay. We must try to use the new situation to the advantage of women, which does not mean that we should accept it off hand.

Unemployment among women in one sector and lack of skilled and well educated workers in the other is an inbalance that affects society in many ways. Unions in Sweden have been putting in a lot of effort to educate and train female unemployed workers to the use of computers.

This is important not only for the sake of employment in itself, but also as a message to the employers and to women among themselves: Women want the knowledge because they want the options and the development of their jobs.

Swedish legislation provides most of the framework for a truly equal labour market. Equal pay to men and women, and equal career opportunities are often considered as being reforms fully accomplished. It is the aim of the government to provide for good day-care for all children, thus offering career chances to most women as well as to the men. The social security system allows for parental leave for childbirth and child-care to both parents.

However, given the divided labour market, so far few fathers take full advantage of the possibilities for parental leave. Recent numbers state that 1 out of 5 fathers of newborn babies accept social security for child-care, and this brave pioneer father is often publicly employed, i e used to work with women colleagues... The obstacles are thus partly to be found in attitudes among both men and women, but there is also an economic reality behind the fact that more women than men take parental leave. Measures have been discussed to encourage more men to take this chance of getting to know their children from an early age, but so far only mild restrictions have been applied to this effect. More restrictions and control is one way of enforcing equality - but even such measures won't be effective as long as women are more commonly employed in sectors where jobs are less paid, or where unemployment occurs more frequently.

This is one example of how the divided labour market strikes at attempts to create,equality. Thus it is essential that employers and unions find new ways to encourage a transition in this respect. Recently, some interesting studies about mens roles have been started at the initiative of the Swedish Ministry of Labour (4). This field of study will no doubt grow more important and create more discussion in the years to come.

In some of the big enterprises in Sweden, like the Volvo group, surveys have been carried out to form the basis for the company policy on equality. It is interesting that one report (5) strongly states the importance of the participation of the men to modify old traditional roles in the company and to promote change.

7 Concluding remarks

Revolution cannot be achieved overnight. The struggle for equality, including women's equal chances within all fields of education and working life, needs to be consistently and perseveringly pursued on all fronts simultaneously.

We have collected all the knowledge we need to make the case clear. This knowledge must now be very strongly brought to the attention of politicians and policy makers within government and authorities, companies and organizations and form a basis for change. To do so, we need the idealism, the commitment and the vitality of field workers, in unions and in political parties, in education and research and everywhere in working life, displaying also the diversity of women's knowledge and experience.

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IS THERE A PLACE FOR WOMEN IN BIOSCIENCES?

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SUMMARY

In Finland we have many female students in the field of biosciences but relatively few female scientists, especially senior scientists. We discuss some of the reasons, why women do not start to make science and why even fewer continue to become senior scientists. We think that society needs women for several reasons. The life experiences of women must be considered when making science to counterbalance those of men. This is especially important when women are the target of the study.

As there is an interaction between biology and society the results of bioscientific work will affect the everyday life of women. It is only natural to think that women should participate in developing the picture of women in society.

Biosciences need a change in paradigm towards a view that considers the whole as such, not just as an addition of its parts. Traditional women experiences might make it easier for women to comprise such a way of thinking also in science.

Approximately 70 per cent of the students in the fields of biosciences are women in Abo, Finland. However, when we take a closer look at the situation in the corresponding fields of sciences, it is not what could be expected. In the two universities in our home town, Abo, the percentage of females among younger scientists is 27 and among senior scientists it is only 11.

Among medical students the situation is somewhat different. A doctor' s degree in medical sciences doesn' t necessarily lead to a carieer as a scientist, but to qualified positions in hospitals. Therefore the highest proportion of female doctors can be found in the medical field. With this in mind we looked upon the percentage of females, who received a grant from the Medical Research Comission of the Academy of Finland during the last three years. Among those who received the grant as a younger scientist 28% were women, and among the senior scientists the corresponding figure was 19. This should be regarded against the fact, that a majority (more than 65% during the last ten years) of those who were admitted to the medical faculty consisted of women. Last autumn the Medical Faculty of the University of Helsingfors founded a working group, which had to consider whether a guotient in favour of men should be set. The medical professors were concerned about how the overrepresentation of women in the medical faculty would effect the future of biomedical sciences in Finland.

As we can see from the above mentioned facts, women do not contribute to the development of biosciences in a degree that would correspond to their education in the field. The reasons, why women do not choose science as a profession, although health care traditionally has interested women, are probably manifold and complex. Women may be afraid that a serious participation in scientific work will choose away "everything else". They feel that science will interfere with their experiances of deeper human relationships and motherhood as well as other meaningful activities in life. Another reason affecting the choise of women is that they might have to work in very patriarchal conditions, which may seem discouraging. An example of such a field is gynecology where the absolute majority of teachers are men with their life experiences, relations and world views. Therefore women working in such conditions may feel alienated towards the way of thinking of their teachers and potential colleagues. It may also lead to a situation where the woman scientist finds her job meaningless and unimportant.

Even when a woman has decided to do research she will encounter special problems that are related to her sex. The importance of informal networks has much been emphasized lately. To be able to continue and develop the scientific work, a scientist has to become accepted in the scientific community, which to a great extent is functioning through networks. This is where the personal scientific problems are discussed and advices for applications of scholarships and jobs are given to those in favour. The practical realization of networks often involves meetings from which women are naturally excluded (for instance because of the time of day when they take place).

Another typical problem for female scientists is the lack of female patterns for her work as a scientist. She will have to make her own paths, and often all by herself, without the support of other female scientists. She will often be the one, who works very efficiently eight hours instead of "taking it easy" twelve hours a day. these may be some of the reasons why we have relatively few senior female scientists in Finland although we have many female students.

We think that society needs an increased participation of women in biosciences. The small number of women means that patriarchal values, beliefs

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and biases determines the assumptions made, the questions asked, what is seen and what is failed to be seen and how the data are interpreted. The practice of science can thus become skewed and distorted. A well known and descriptive example is the use in many scientific studies of a seventy kg, non-cycling person as a standard human being. This way of thinking makes normal female functions, like menstruation and pregnancy seem strange and even pathological. The concept of "premenstrual tension" is today used as an explanation to all kinds of unsatisfied behavior in women. In many western countries midwifery has been excluded and pregnancy and delivery have become technical problems.

The view of humans as being comparable to machines is a widely supported one among scientists today. This view has alienated many persons from the classical medical care and driven them to seek alternative health care methods. Therefore the paradigms in biosciences today need to be changed and the view of humans as a social, psychological and organic whole should be emphasized. The different experiences of women in their daily lives might make it easier for them to realize the importance of such a paradigm shift. The method of natural sciences is to make a simple model of the complex and then to study this model systematically taken out of its context. Very often scientist, however, forgets the simplification s/he started with and try to make up a central dogma of it into which everything is supposed to fit. If the empirical facts do not fit, the scientist really don't recognize them or throw them away as a mistake. According to our view, this is a situation harder to accept for women than for men, perhaps because men usually have greater ambitions and want to succeed no matter what the price of it will be. It is characteristic that it is Barbara McClintock who tells us to "listen to the material and let the experiment tell us what to do". She also very wisely says "the success of a theory is measured not by its simplicity but by its fidelity to the intricate variety of natural phenomena'',

Biased studies, which a priori assume differences between sexes because of the social reality at hand have been performed in all times. The results of such studies have been that it is a dangerous chimere to pose the same goals for both sexes and to warn about the consequences for society if women are allowed to make carrieers of their own .

Finally, we do think it necessary to change the way of thinking in biosciences. We also think that women should contribute to this paradigm change, because they are the ones who do not get on so well in the scientific community.

More over, we find it very important for women themselves that they would participate and consider the conditions of half of the earth' s population according to their own values and life views.

However, we think that the most important is not only to get an increased number of female scientists , but to have a feminine world view introduced, a world view emphsizing the whole as such and not only as an addition of its parts.

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AN EVALUATION OF EFFORTS MADE IN NIGERIA TO INCREASE THE PARTICIPATION OF GIRLS AND WOMEN IN SCIENCE & TECHNOLOGY.

Paper prepared for GASAT 4, 1987
by

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Introduction

The phenomenon of under representation of women in science and technology (S & T) courses and occupations in almost all countries has been extensively documented and so needs no further emphasis. What is important is to report efforts being made in different countries to correct the imbalance. Some of these are already reported in literature or in proceedings of GASAT conferences I, II and III. Nigeria, a developing country is not oblivious of the need to have more women participate in S & T. As far back as 1969 when the first ever national curriculum conference was held, the recommendations to the Federal Government on the Education of women as well as on the Role of Science and Technology included:

1. "Intensify propaganda by all available means about girls' education.
2. Attempt, through education and all the communication channels to change societal attitudes to girls' education.
3. Diversify school curriculum and gear this towards the needs of all children, including girls" Adaralegbe (ed) 1972 p. 149.

23. "Diversify the science and technology curriculum to permit teaching of pure and applied science in our secondary and teacher training colleges.

27. Specially encourage girls to pick up science and technological training" Adaralegbe (ed) 1972 p. 210.

These and other related recommendations in that conference as they relate to the issue of women in S & T can be summarised to read that the Federal Government must:

1. Raise public awareness of low participation of women in S & T and proceed to specially encourage girls to enter S & T.
2. Utilise formal and informal education processes to change societal

attitude and values to girls education.

3. Diversify the curriculum at all levels to include topics of relevance to the needs of all including girls.

The focus of this paper is an examination of the extent to which these recommendations have been implemented, the effects in the enrolment of women in S & T. The paper will in the light of what is going on in other countries make further suggestions on Nigerian women's participation in S & T

Before continuing, an important assumption must be made and that is that any step taken to create opportunities for women to go to school and stay in school is a step towards increasing the proportion of women enrolling in S & T courses and careers. This is because only when the girl is given access to formal education would there be opportunity for any one to steer her into S & T. In short this discussion may go a little beyond the scope of S & T especially as it concerns country struggling to encourage her girls to go to school.

Raising Public Awareness

It is absolutely necessary to differentiate between awareness and concern. Awareness is a prerequisite to concern, but concern may not necessarily follow awareness. In the case of Nigeria public statements and releases of the government, public speeches by many Nigerians on education, as well as published reports on matters concerning women seem to point to the fact that there is a substantial degree of awareness. A random sample of 100 educated Nigerians interviewed on the low participation of women in S & T indicated that they all are aware but of all these only 38 expressed serious concern. The lack of concern is explained by the strong cultural views of most Nigerians that males are superior to females and it is only normal and expected that more males than females take to S & T-fields considered challenging and prestigious.

In Nigeria the mass media - newspapers, radio broadcasts, television programmes have been used to raise public awareness and concern. The various Nigerian dailies that carry articles on science and technology have occasionally published extracts of statistics showing the low enrolment of women in S & T. Sometimes these dailies and even some periodicals have carried write-ups or profiles of some successful Nigerian women in S&T occupations (Sunday Guardian Nov.18, 1984, Dec.28, 1986; Sunday Concord March 3, 1985; Sunday Times Nov.19, 1984; Sunday Sketch Nov., 1984). Radio broadcasts and Television programmes have run commentaries on selected women who have succeeded in S & T. One believes that the accessibility of these media to a good proportion of literate Nigerians, would be having a positive effect on the concern of public to low participation of women in S & T.

Seminars, conferences, symposia, workshops are effective means of propaganda. These have not been fully utilised in Nigeria to raise the desired awareness and concern. In fact only very few publications on women in S & T exist and are relatively recent (Okeke, 1986 and Osibodu, 1985). Perhaps the lack of any special organisation or pressure group specially concerned about women in S & T may account for the non-utilisation of these means of creating public awareness. It is gratifying to report here that in August, 1986, a Women Education Unit was set in the Federal Ministry of Education, Lagos, with the responsibility of implementing women education programmes and the recommendations set out in the recently produced Draft Blue Print on Women Education. The recommendations if implemented will enhance the opportunities of Nigerian women to enter S & T. A conference is being planned for 1987.

Apart from using social institutions to bring awareness, at times government have stepped in with back up laws and edicts. An example is the edict enacted in Borno State of Nigeria, 1985 making it a punishable offence for parents who prematurely withdraw their girls from school to give them away for early marriage. Such government supports have been known to be quite effective.

Changing Societal Attitudes and Values

Societal attitudes to girls education and career favour sex stereotyping; that is to say whatever education is offered to girls, this must lead them to fulfill stereotyped sex roles. Since this attitude and values are entrenched in tradition and culture efforts to change them demands actions directed to modify a culture that places women as second rate citizens. To this end, any person or group of persons that seek equal opportunities in all its ramifications for men and women is fighting sex stereotyping and consequently encouraging the participation of women in S & T. In Nigeria there are a number of women groups who seek better treatment and recognition of women in Nigeria's development. There is the National Council of Women's Societies (NCWS) which co-ordinates the activities of affiliated women societies/associations whose objective is to seek the welfare of women through reducing the societal biases and prejudice which hinder the success of women in education and development. Other organisations in Nigeria that have run conferences/seminars aimed at making the public aware of the sufferings of Nigerian women as imposed on her by legal and social institutions include "Women in Nigeria" (WIN), "Nigerian Association of University Women" (NAUW). These organisations have greater followership among the elite women in Nigeria. There are also women in professions and businesses, eg. "Association of Professional and Business Women" (APBW), Association of Professional Women Engineers (APWE), etc. Each of these and many others have through their fight to improve the working conditions of the women in professions and ensure non-discrimination in their career prospects have contributed immensely to reduce sex stereotyping. They have through their contributions changed attitude of society to the capabilities of women, serving also as role model for young females.

Diversifying the Curriculum

A bold attempt to diversify the curriculum in Nigeria came with the modification of the educational system in 1982. The 6 years primary, 3 years junior secondary, 3 years senior secondary school, and 4 years University education now referred to as 6-3-3-4 system of education has a number of features that depict the diversification of the curriculum. There is the pursuit of primary science teaching so that every Nigerian child would have access to science concepts and skills. There are many new subjects in junior secondary school that are in area of S & T. These are Integrated Science, Introductory Technology, Home Economics, Welding, Smithing, Woodwork etc. By making these subjects compulsory to both boys and girls one can see that girls are obtaining greater access to S & T. Provision for counselling and guidance services have been emphasised. The only problem is in the implementation, since such diversification requires heavy financing. A few states in Nigeria have vigorously pursued the implementation and it is hoped that by 1988 all states would have complied. Though it would appear that both boys and girls are given equal opportunity it is known that the concepts, skills and processes, built-in attitudes, prevailing teacher interaction styles in favour of boys, language and content of texts and examination questions, put the girls at a disadvantage. However, the fact that the curriculum in Nigeria schools bear great similarity with those of Britain would lead one to believe that the present trend in Britain to diversify curriculum to enhance women participation in S & T will influence curriculum works in Nigeria. In this direction curriculum analysis of S & T courses, analysis of texts, analysis of teacher interaction styles, analysis of science and technology tasks as they relate to girls and S & T is a fertile ground of curriculum research in Nigeria.

From the discussions so far there is reason to believe that the recommendations of the 1969 conference as they touch on women education, science and technology are being pursued, albeit not as vigorously as the situation demands. It is important all the same to examine the effects of these implementations.

Results of Actions so far taken

Considering the actions already taken to tackle the issue of under-representation of women in education especially in S & T, one expects significant improvement in the enrolment figures of girls in S & T and in science based occupations. The figures contained in the following 2 tables speak for themselves. There has been steady increase in number and proportion of women enrolling for S & T subjects and occupations. It might interest readers then in two states of Nigeria (Anambra & Imo) the girls are beginning to out-number boys in secondary schools enrolment.

Table 1

ENTRIES OF CANDIDATES BY SEX IN STM SUBJECTS FOR THE BEGINNING AND TERMINAL YEARS OF THE PERIOD (1980 - 1984)

Subject	No. Sat 1980	No. Sat 1984	% Increase
Maths	M - 105320	247328	134.83
	F - 50261	156576	211.32
Statistics	M - 894	1922	114.99
	F - 231	620	168.40
Add. Maths.	M - 4306	7422	72.36
	F - 535	1264	136.26
Physics	M - 23608	53290	125.73
	F - 4265	12191	185.84
Chemistry	M - 49648	77835	56.77
	F - 16522	39374	138.31
Biology	M - 90997	180106	97.93
	F - 43671	130396	198.59
Tech. Drawing	M - 2480	7396	198.23
	F - 98	476	385.71
Wood Work	M - 353	1298	267.71
	F - -	12	-
Metal Work	M - 635	870	37.01
	F - 4	6	50.00
Applied Elec.	M - 371	1310	253.10
	F - 11	62	463.64
Basic Elect.	M - 135	274	102.96
	F - 5	24	380.00

Subject	No. Sat 1980	No. Sat 1984	% Increase
Auto Mechanics	M - 13	743	248.83
	F - 0	12	-

In the above Table, the percentage increases of entries in STM subjects from 1980 to 1984 are shown. The table reveals that the percentage increases in entries for girls are more for nearly all the subjects than for boys.

Table 2

Percentages* Female University (Federal) Graduates by Faculty and Sex, 1980 - 1984

Faculty	1980/81	1981/82	1982/83	1983/84
Business Administration	9.9	9.6	10.5	17.2
Agriculture	13.4	13.6	8.2	12.4
Engineering/Technology	4.5	3.0	4.2	4.3
Environmental Design	8.9	8.2	6.4	10.1
Medicine	17.1	21.6	26.7	26.5
Pharmacy	22.3	27.0	26.0	35.4
Sciences	15.6	17.1	18.0	21.6
Veterinary Medicine	8.5	4.9	8.6	7.0

*This includes about 2 per cent who enrolled in diploma and other non-degree courses.

Source: Federal Ministry of Education, Lagos.

While it can be said that the various actions undertaken have yielded positive results, significantly low proportion of women are in S & T. Further suggestions which form the third and last part of this paper, if implemented will increase the proportion of women in S & T.

Further Actions Recommended

1. Public awareness and concern requires to be further raised especially among teachers who through their classroom interaction reinforce sex-stereotyping and steer girls out of S & T. Other groups to whom the propaganda need to be directed are parents who carry strong societal views on sex roles; curriculum workers and textbook writers, and finally examination bodies such as W.A.E Council.
2. Formation of pressure groups to initiate, sustain, and co-ordinate

actions introduced in the country to get more women participate in S & T. For instance, within the unit of Federal Ministry charged with the education of women, a sub-unit needs to be created to promote and monitor the education of women in S & T.

3. Government and Universities can consider reducing cut off points or quota to women in the admission into S & T courses. Mamulwanye (1987) reports actions in this direction for entry into Junior Secondary Schools in Zambia. Or special science and technology colleges can be set up just for girls to reduce the imbalance.
4. Provision of facilities to enable married women to function comfortably in S & T jobs while keeping their other functions as mothers and home makers.
5. Including more women in decision making bodies so that the interest of women can be catered for especially in those areas such as S & T where women had hitherto not been prominent.
6. Pre-service and in-service courses for guidance counsellors to include their role in getting more women to participate in S & T. Greater use of role models should be included in the curriculum.

It is hoped that if these recommendations are implemented more women will participate in Science and Technology.

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DESEXING COMPUTING

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This paper describes a series of studies examining girls' and womens' attitudes to computing and evaluates a programme of workshops designed to make computing a more positive experience for women students.

All the evidence, both in the United Kingdom and the United States, suggests that new technology in general, and computing in particular, are in danger of joining maths, physics and engineering as male preserves. In Britain, boys are 13 times more likely than girls to use home computers; over 75% of students taking 'O' and 'A' Level examinations in computer studies are male; less than 20% of the degrees in computer science are awarded to women; and where women are employed in the computing industry the vast majority consistently perform lower status tasks, such as data preparation and entry, and wordprocessing. Furthermore, a major retailer in the United Kingdom reports that 85% of their customers for computer magazines and video games are male. A similar pattern is evident in the United States (e.g. Fetler, 1985; Hess and Miura, 1985).

A series of studies carried out under my supervision in the last three years provide empirical support for the existence of clear sex differences among children and adults in attitudes toward computers in the context of school, home and society in general. Although the three studies differed in their focus and sampled different populations they all point to the same disturbing conclusion: girls and women are less interested in and are less likely to know how to use a computer than boys and men. Two of the studies focussed on attitudes to computing and mathematics and experience of computing among children.

A survey of 217 pupils (86 girls and 131 boys) aged between 13 and 16 years attending a co-educational secondary school showed that, although girls felt that it was equally important for girls and boys to know about computing and mathematics and that girls had the ability to learn about these subjects, they were significantly less interested in them and found them less enjoyable than did boys. The vast majority of the sample had been taught to use a computer by a male teacher and whereas over half of the boys in the sample said they had also taught themselves to use a computer this was true for less than one girl in ten. Girls were significantly less likely than boys to know how to use a computer or to have access to one at home and, even if one were available, they used it less frequently than did boys. For both girls and boys attitudes to computing and mathematics were positively correlated, and for boys interest, enjoyment and confidence in computing were all greater among those boys who used a computer at home. These differences were reflected in the job choices nominated by girls and boys, with the majority of girls choosing stereotypically female jobs, the largest proportion of which involved a caring role with respect to children or animals, and only 3.5% mentioning a job involving mathematics, science or computing. In contrast, nearly a quarter of the boys wanted a job in one of these areas and just over 10% specifically nominated computing as their first choice.

A second study involved a sample of 178 children (92 girls and 86 boys) aged between 11 and 16 drawn from a secondary school of 1400 pupils. Computer studies was offered as an examination subject at various levels in the school and was taught by a female teacher, but in line with the statistical evidence less than a quarter of the children taking these examinations were girls. The research showed that girls were significantly less enthusiastic about computers in general, were less confident with computers and saw them as having more negative social consequences (e.g. increased unemployment and reduced contact among people) and as of less value to society than did boys. Furthermore, girls' attitudes to computers were significantly related to their perceived ability in, and attitudes to mathematics, and to various personality variables. 'Computer enthusiast' girls were likely to be better at mathematics, more ambitious, more self-sufficient, less sociable and less person-orientated than those girls who displayed negative attitudes, whereas the corresponding groups of boys could not be differentiated on the basis of their personality or mathematics ability.

A difference in the way computers are perceived also emerged in the final study in this series which compared the attitudes of men and women toward wordprocessing and computing within a sample of 68 adults. The findings reinforce the view that females see computers as dehumanising and as a source of anxiety and of control. Women were significantly more likely to express a preference for people over machines, to believe that money should be spent on social welfare rather than on computer technology and to believe that increased use of computers will contribute to rising unemployment and stress. This attitude did not extend to wordprocessing which women were more likely than men to see as a necessity in today's society and as accessible to all regardless of their intelligence. However, women were also more likely than men to see wordprocessing as a female occupation, with three quarters of the women in the sample holding this stereotype (cf. Hawkins, 1985). Thus, women's positive attitude is restricted to what is seen as primarily a female domain.

These findings all converged to suggest that unless steps were taken to encourage women to adopt a positive attitude toward computers, and, more importantly, to engender in women a willingness to acquire computing skills, then the majority of women would continue to be at a disadvantage compared with men in an increasingly technological world. Clearly exposure to computers and the opportunity to take courses in computing are by themselves insufficient to stimulate interest in computing among girls or to guarantee that they will wish to acquire computing skills. This suggests that women would benefit from a learning environment which offers them the chance to become familiar with computers and their applications without feeling at a disadvantage in comparison with other students who are perceived as confident about their ability to handle 'machines' and as competent to some degree. Such students are usually male. Thus, girls may not only lack interest and motivation but their participation in class may be further reduced if boys react with confidence and assert their control over the equipment. This is of particular importance since experimental research suggests that when carrying out a task in a mixed group the confidence of females is equal to that of males only when they have been provided with the opportunity to develop task-related competencies prior to joining the group (e.g Stake and Stake, 1979).

At the time that I was assimilating this information I had recently been appointed to the newly created post of Adviser to Women Students at the London School of Economics. The Adviser is available to discuss all the issues of concern to women students in the School and she has a positive commitment to taking new initiatives which may improve the quality of life of women stduents in the future. The School has just over 4,500 students of whom 39% are women which is about the U.K. national average in higher education. This means that women frequently find themselves in a minority in lectures and seminars. Moreover, the number of women academics at LSE is extremely low, even in departments with a high proportion of women students (e.g. in Social Psychology where three-quarters of the students are women only one of the ten members of staff is a woman), and in some departments there are no women academics at all. This means that women students rarely have a woman tutor, teacher or supervisor. The School offers a wide variety of undergraduate and post-graduate degree courses in all aspects of the social sciences and many of these courses either require or strongly recommend that students should acquire some computing skills. These skills may include computer programming or the use of interactive packages for data management or for statistical analysis, and may require the student to be familiar with an array of software implemented on a range of different machines, both micro-computers and remote main-frame devices. In addition to those students who face explicit computing requirements, an increasing number of students with little training in quantitative methods are collecting research data, the analysis of which could be greatly aided by the use of a computer. Moreover, the majority of students are keen to beomce competent in using a wordprocessing package in order to facilitate the preparation of their course work assignments, and a minority of departments provide training in the use of these packages.

Any student, male or female, who does not receive formal training in computer skills has to find out what facilities are available, locate the appropriate documentation, venture into one of the terminal rooms set aside for student use - which will usually be occupied mainly by men - and work out what to do by trial-and-error. This can be a daunting task for any individual who feels hesitant about their abilities but it is even more frightening if you have rarely if ever touched a computer keyboard; if you see computers as demanding mathematical skill, as inherently dehumanising and as merely confirming your image of yourself as inadequate with respect to machines. With some exceptions this is likely to be your experience as a woman student.

These were my perceptions and so as Adviser to Women Students I organised a series of computer familiarization workshops which were designed to introduce women to the computing facilities available in the School and to some of their uses, such as numerical analysis and word-processing. The courses received an enthusiastic response and were fully subscribed being attended by a total of nearly 100 students. It was disturbing to note that not everyone in the academic community was in

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favour of women-only courses. Despite the fact that publicity about the workshops provided the statistical evidence why computer workshops for women are necessary and likely to prove popular, articles and letters appeared in the student newspaper ridiculing the scheme, and some academics questioned whether there was a 'real need'. The answer is clear: although women clearly appreciate the need to be computer literate, their schooling rarely provides to opportunity for them to acquire computing skills and this lack of knowledge, combined with a dislike and often fear of computers, means that they are unlikely to acquire these skills without the support of a positive and non-threatening environment.

In order to evaluate how far the workshops had fulfilled their aim each student was asked to complete two questionnaires. The first of these, which was completed prior to the workshop, asked students what they thought of when they heard the words 'computing' or 'computers', what experience they had of using computers, why they wanted to learn to use computers and their current expectations vis-a-vis computing. A content analysis of the answers to these open-ended questions revealed a clear pattern in the responses. The dominant reactions to computers were fear, intimidation and mystification. Computing was seen as an essential skill but as difficult, mathematical and inaccessible. The consensual view was encapsulated in the response of one student who said 'Help! I go blank when I see a computer or a totally incomprehensible computing manual. Computing is "secret knowledge" which everyone else seems to have and which I feel I ought to know about but don't, and so it is too embarrassing to ask'. The majority of the students had little or no experience of using a computer and felt that they had 'missed out' on an important aspect of education. They felt that it was important to know something about how to operate computers and about their applications and, depending on their course of study, they emphasised either wordprocessing or data analysis. A recurrent theme was the wish to feel less afraid and more confident about using computers and to feel able to ask questions without embarrassment. Many students felt they had no chance of achieving this unless women-only sessions were arranged as 'it is too frightening to walk into a room full of computer "buffs"'.

The second questionnaire indicated that with respect to computing and computers the feelings of some 90% of the students who had attended the workshop had changed in a positive direction. They felt less frightened and more confident; they saw computers as less mysterious and more accessible; and they wanted to go on to learn more. A number of students expressed some surprise at the fact that they found computing fun and enjoyable, and emphasised the contrast with their negative experience of computers at school. Again, the dominant view is summarised by the student who said: ' I have gained a lot of confidence; the fear of doing something terribly wrong has gone; I feel able to enter the computer room and have a go, which is something I could not have done before now'. The minority of students who had not changed their views fell into two groups; those who did not see a use for computing skills at the moment and those who still saw computing as difficult and felt they needed more time and practice to overcome their apprehension. The wish to extend the length of the workshop was not restricted to this handful of students, with half of the group endorsing the view that the workshop was too short and suggesting that it should be extended to allow more time for women to practice their newly acquired computing skills in a supportive setting. Otherwise the reactions were very positive with between 70% and 83% saying the workshop was enjoyable, useful, informative and clear. It is interesting to note that multiple regression analyses revealed that different attributes predicted enjoyment of the session focussing on numerical analysis and that dealing with wordprocessing. Whereas information content significantly predicted enjoyment of the numerically-oriented session, perceived usefulness predicted enjoyment of the wordprocessing session.

The positive response to this programme of workshops has clear implications for the future involvement of women in computing. There are practical steps which can and must be taken now to counteract the negative attitudes and concomitant stereotypical perceptions of computers held by many girls and women. On the basis of the success of the workshops run this year I plan to continue the initiative next academic session, extending the length of the workshops and making them available to women staff, a number of whom have expressed similar fears to those identified by students. The workshops have shown that even women who are afraid of using computers can rapidly acquire sufficient confidence to continue the learning process and to enjoy computing if the information is presented to them in a non-threatening setting. Such positive action is necessary if women are to be computer-literate and current employment inequalities are not to be exacerbated.

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Acknowledgements

I would like to express my thanks to the women who have contributed to this paper: Jennifer James, Helen Kent and Catrin Morrissey who conducted the empirical studies; Laura Markowe and Tracy Mead who assisted me in the running of the workshops and all those who took part.

A BIBLIOMETRIC STUDY OF THE WISEST WOMEN IN PURE AND APPLIED SCIENCE BIBLIOGRAPHY

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WISEST (Women in Scholarship, Engineering, Science and Technology) is a Task Force at the University of Alberta, established by Dr. J.G. Kaplan, Vice-President (Research). Among its many activities[1], WISEST sponsors a computer-based online bibliographic database of monographs, analytics from monographs (chapters, papers), and articles from journals dealing with women and science. The online database is called WISEST; the printed product is called *WISEST: Women in Pure and Applied Science Bibliography*. At the time of this study, the database included 2300 items.

The dbms (database management system) used to maintain WISEST is SPIRES (Standford Public Information REtrieval System), available at the University of Alberta on an Amdahl 5870, a large main-frame computer which uses MTS (Michigan Terminal System) as the operating system. The data for this paper was collected using an IBM PC as a terminal and PCTIE, a communications program (developed at the University of Alberta).

SPIRES is a very flexible dbms which provides the owner of the database with a great deal of flexibility in both the design of the database and the resulting products, along with a powerful online search command language and standard product formats.

Advantages of using the large mainframe computer include: online multiple user access, easy updating and editing of the database, SPIRES consultants, quality products (including multiple copies), hardware and software maintenance, and reliable system backup. A grant from WISEST plus the availability of a special research rate from Computing Services makes it financially attractive as well.

A database consists of data records (a bibliographic reference is one data record) which are made up of data elements (e.g. author, title, pages, etc.). The dbms then creates indexes from specified data elements (e.g. author, date, etc.).

Data elements in WISEST include: date-added, date-updated, data-type, ID, title, author, edition, source, publication-date, pagination, series, ISBN, ISSN, descriptors (empty at present), notes, library location and call-number (at the University of Alberta), and a biblio-code (to indicate where the item was found).

WISEST can be searched on the following indexes: document-type, author, title word, source, publication-date, library-location, and descriptor (empty).

SPIRES provides a default format for all databases which allows the user to select the data elements to be printed (with their labels). It also provides a report generator which can be used on any database and works from the data elements as well. In addition, each database owner can create unique formats for that database. WISEST has three of these specific formats: one for the printed bibliography, one for online screen display (with the University of Alberta library locations) and one for the owner (with the data record ID which is needed for editing).

The inverted indexes created by SPIRES are readily searched using the standard SPIRES command language. In addition, SPIRES allows for searching on data elements that are not indexed. Searches can be refined using Boolean logic to narrow searches ("and" - both search terms must be present: "not" - a search term must not be present) and to broaden searches ("or" - either term can be present). Searches can also be broadened by using word stems and the truncation symbol (#). Thus CHEM# will retrieve all items beginning with CHEM - CHEMISTRY, CHEMISTS, CHEMICAL, etc.

SPIRES also allows for sequencing of the records before the results are printed, again using the data elements. Search results can be printed in alphabetical order by author, title, source, date-added, etc.

BIBLIOMETRICS

"Bibliometrics" was first coined as a term by Alan Pritchard in 1969, replacing the earlier term "statistical bibliography".

> The definition and purpose of bibliometrics is to shed light on the process of written communications and of the nature and course of a discipline (in so far as this is displayed through written communication) by means of counting and analysing the various facets of written communication.[2]

Bibliometric studies are usually done either on bibliographies (including indexing and abstracting services) or on citations found in a particular collection of documents. [An excellent review of the literature can be found in the Annual Review of Information Science and Technology.[3]]

These counts were originally done by hand and it took considerable time to collect, record, and analyze the data. It is now possible to use online databases and the power of the dbms to do these counts. Formats can be used to produce various lists of data elements in desired sequences which can then be rapidly hand-counted.

The following bibliometric study of the WISEST database illustrates how the SPIRES dbms can be used to extract data easily and quickly. The results can be used to describe the characteristics of the literature, identify the most productive authors and journals, help design a descriptor list, identify items for collection building, and find errors.

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DATA TYPES

There are three types of items included in the database: mongraphs (dt=3), analytics from monographs (dt=1) and articles from journals (dt=2). Simple searches of the data type index provide the information that, of the 2300 items in the database:

595 (25.9%) are monographs
430 (18.7%) are analytics from monographs
1275 (55.4%) are articles from journals

Additional searches using the Boolean logic to combine data-type with specific data elements provide the information that:

229 (38.5%) of the monographs are ERIC documents
152 (25.7%) of the monographs are THESES
123 (28.6%) of the analytics are from the GASAT conferences
41 (3.22%) of the articles are BOOK REVIEWS
20 (3.36%) of the monographs have BIBLIOGRAPHY in the title

By searching for the word INDIVIDUALLY in the note element, monographs and special journal issues that have been analyzed can be identified.

24 monographs are analyzed producing 377 records of dt=1
11 journal issues are analyzed producing 122 records of dt=2

PUBLICATION-DATE

Publication-date frequency counts are presented in GRAPH 1. (by decade, 1910-1970) and GRAPH 2. (from 1970-1986). GRAPH 2. demonstrates the time lag which results from the fact that most of the items come from secondary sources. After a period of rapid growth in the 1970's, the amount of literature produced on women and science appears to have stabilized somewhat in the 1980's.

The peaks in 1981, 1983 and 1985 are interesting and the importance of the GASAT conferences to the literature of women and science might be indicated. By searching for GASAT in the source element for dt=1 (analytics), in combination with publication-date, the number of papers given at each conference can be isolated.

21 papers were given at the 1981 GASAT conference
32 papers were given at the 1983 GASAT conference
70 papers were given at the 1985 GASAT conference

GRAPH 3. shows the effect of the GASAT conferences on the literature during the 1980's. Even without the GASAT papers, 1981 and 1983 still show slight peaks which might suggest a spill-over effect.

Space does not permit the inclusion of the data here, but the number of items by data-type per year was also readily obtained. As can be seen in TABLE 1., an increase has occurred in the number of analytics while articles from journals still count for over 50% of the items. In bibliometric studies, emphasis on papers and articles is usually considered to be the sign of an active, developing field, with a need for rapid exchange of information (compared to the production of more definitive monographs by an older, established field).

AUTHORS

The SPIRES report generator was used to print out all the authors in alphabetic order. Simple hand-counts then provided a list of the number of items for each author. Since these will be only the first named author if there are joint authors, the most productive authors were checked online for the total number of records per author. TABLE 2. lists the most productive authors in the WISEST database. One result of such lists could be to check indexing and abstracting services under these names and/or write the authors directly to make sure that all their relevant items are included in the database.

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Author frequency counts are presented in GRAPH 4. (without the 1214 authors with one item each). The data demonstrates the typical bibliometric distribution where a few authors produce numerous items each, while a large number of authors produce one or two items each.

There are 1498 different authors who have produced 2182 items (118 items do not have an identifiable personal author). There are 23 (1.54%) authors who have produced 7 or more items each as first author for a total of 282 (12.9%) items while 1214 (81.0%) authors produced one item each as first author for a total of 1214 (55.6%) items. Over 90% of the authors have produced only one or two items for a total of 1374 (63.0%) items. This suggests a very diverse literature where many authors are responsible for producing the literature of the field.

TITLE WORDS

A special program was written by a SPIRES consultant to provide a list of all the individual title words along with frequency counts. TABLE 3. gives a list of the 40 most used words. It is not suprising to find that the words with the highest frequency are women, science, mathematics, sex, differences, girls and engineering. This would indicate that authors in the field use descriptive titles. In fact, using truncation and Boolean logic to seach for WOM# or FEM# or GIRL# in the title produces 1453 items or 63.2% of the database.

GRAPH 5. presents the title word frequency counts excluding the 48 words which occurred over 40 times and the 1581 words which occurred once.

The next step will be to take these lists and use them as the basis for developing a controlled vocabulary descriptor list to supplement the free text searching allowed on the title words.

JOURNAL SOURCES

The journal titles for dt=2 (articles from journals) were printed out in alphabetical order. Again, simple hand counts provided the data given in TABLE 4. There are 360 journal titles producing 1275 items with 37 (10.3%) of the journals producing 633 (49.7%) of the items.

TABLE 4. indicates the journals that are most productive and therefore should be scanned as primary sources for articles, rather than waiting for their appearance in the secondary sources. The journal titles can also be checked against abstracting and indexing services to find the most useful secondary sources as well.

JOURNAL SUBJECTS

The journal titles for dt=2 (articles from journals) were printed out in Library of Congress (LC) subject classification code order. These LC codes were then translated to the corresponding subjects and arranged in order of the number of items in TABLE 5.

Of the journals which include articles on women and science, science journals are the most productive, followed by education, social science and technology journals. Women's studies journals (HQ) provide 101 of the 153 records in the social sciences journals.

DATA CHECKING

In spite of all the checking and proofreading of the data before entry into the database, errors and inconsistencies occur. Printing out various lists using the power of SPIRES is an one way to uncover these errors. For example, when the journal titles are printed out in an alphabetic list (rather than scattered throughout the database) errors are easily noted.

Other ways the dbms is used for data checking include: data-type and title elements are required or the record will not add to the database; a list of libary location codes is kept in a separate SPIRES file and again, the record will not add if the code does not match a code on the list; printing out the notes element provides a way to produce a list for checking to ensure consistency; a list of items with location NOT OF A can be used to suggest items for purchase for the library and to determine items that should be obtained on inter-library loan.

CONCLUSIONS

The study has shown the ease of collecting bibliometric data from an online database using the power of the dbms.

The data collected can be used to improve the data basé, identify the most useful journal sources, identify the most productive authors, and provide the basis for developing a list of descriptors.

The literature of women in science has been shown to be very diverse with an emphasis on articles from journals and an increasing emphasis on analytics from monographs (often conference papers). This is usually interpreted as being characteristic of a newer, less established field which has not yet developed a core literature of its own.

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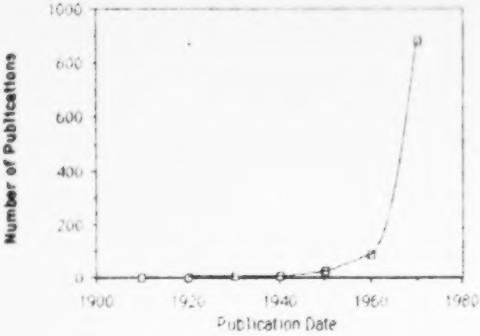
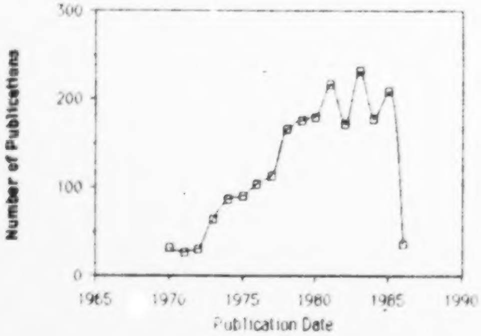
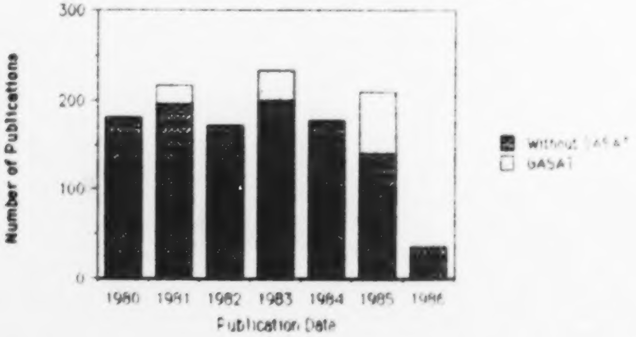
GRAPH 1. Frequency of Publication Date by Decade



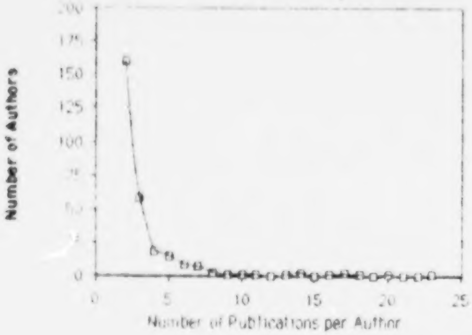
GRAPH 2. Frequency of Publication Date 1970-1986



GRAPH 3. Efeect of GASAT on Number of Publications



GRAPH 4. **Frequency of Publication by Author**



GRAPH 5. **Frequency of Publication by Word**

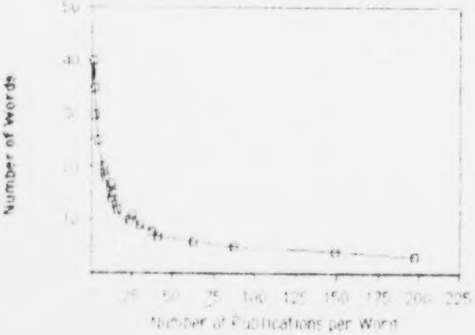


TABLE 1.
Number of Items by Data-Type for 1960's 1970's 1980's

	dt=1	dt=2	dt=3	total
1960's	13(14.6%)	59(66.3%)	17(19.1%)	89
1970's	81(9.2%)	546(61.8%)	256(29.0%)	883
1980's	319(26.1%)	651(53.4%)	250(20.5%)	1220

TABLE 2.
Most Productive Authors

author	number of items as first author	total number of items
Aiken, Lewis R.	7	9
Casserly, Patricia	7	7
Ormerod, M.B.	7	12
Raat, Jan H.	7	8
Rossiter, Margaret W.	7	7
Fee, Elizabeth	7	9
Perry, Georgina	[illegible]	7
Lantz, Alma	6	8
Ott, Mary Diederich	6	8
Tobias, Sheila	8	15
Small, Barbara	9	11
Harding, Jan	10	15
Hubbard, Ruth	11	15
Kahle, Jane Butler	13	13
Astin, Helen S.	14	16
Keller, Evelyn Fox	14	14
Kreinberg, Nancy	15	15
Yost, Edna	16	16
Fox, Lynn H.	17	20
Sherman, Julia	17	21
Vetter, Betty M.	18	18
Fennema, Elizabeth	20	26
Kelly, Alison	23	28

TABLE 3.
Most Used Title Words

word	number of items	word	number of items
women	1023	medicine	62
science	658	scientific	61
mathematics	297	mathematical	59
sex	251	math	58
differences	195	careers	57
girls	180	physics	57
engineering	150	ability	55
achievement	127	gender	55
school	120	male	54
students	119	role	54
education	118	women	54
technology	116	review	53
career	107	college	52
scientists	98	men	52
female	95	participation	50
study	92	research	49
attitudes	86	academic	47
report	71	engineers	45
factors	66	boys	40
high	62	females	40

TABLE 4.
Most Productive Journals

journal title	number of items
Science	50
Journal of Research in Science Teaching	35
New York Academy of Sciences, Annals	33
Chemical & Engineering News	31
New Scientist	27
Impact of Science on Society	25
Engineering Education	24
Physics Today	22
Sex Roles	21
Journal for Research in Mathematics Education	20
Signs	20
Mathematics Teacher	18
International Journal of Women's Studies	18
Journal of Medical Education	18
School Science and Mathematics	18
IEEE Transactions on Education	17
Science Education	16
Arithmetic Teacher	15
American Mathematical Monthly	12
Psychology of Women Quarterly	12
Journal of Educational Psychology	12
School Science Review	12

TABLE 5.
Journal Subject Classification

LC code	subject	number of journals	number of items
Q	Science	62	455
L	Education	88	196
H	Social Sciences	37	153
T	Technology	33	136
B	Philosophy, Psychology	26	58
A	General Works	11	16
S	Agriculture	4	4

Some journals at the University of Alberta are not classified

GUIDELINES FOR SEX EQUITY IN TEXTBOOKS

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ABSTRACT

In order to have school textbooks represent a subject matter which is relevant to both women and men in the schools, guidelines have been formulated for the content of textbooks for different school subjects. This paper concentrates on those for physics and technology, as laid down in the publication "Guidelines for sex equity aspects in textbooks".

After construction of the guidelines, an evaluative survey has been held among researchers, curriculum developers, test developers, counselors, teacher trainers, educational publishers.

The evaluation had to give answer to two questions:

-does the target group agree with the making of guidelines;

-does the target group agree with the guidelines in their actual form.

The response to the questionnaire was about 35%, which isn't overwhelming. Response came mainly from those already interested in sex equity. Among respondents, agreement with the guidelines was very high, as with the importance of paying attention to sex equity in education.

A considerable number of good suggestions came out of the open ended questions in the survey.

The paper relates some of the results of the survey.

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The research reported here concentrated on the male bias in the content of science and technology teaching, as it is laid down in the textbooks.

It was presumed that one of the causes for the low representation of young women in science and technology education resided in the fact that textbooks reflect male oriented sex roles. The research has been executed by the Advisory Group for Learning Materials, an advisory board to the Dutch Minister of Education, and at his request.

What he asked was to

> "construct guidelines which can be used by teachers to test aspects concerning sex equity in learning materials and which authors and editors of textbooks can apply in writing and illustrating new material or in preparing reprints".

The research passes through the following stages:

1. analysis of existing materials,
2. identification of problems,
3. delineation of the research field,
4. collection of data,
5. construction of guidelines,
6. evaluation of the instrument,
7. definitive version of guidelines.

This report concentrates on stages 5 and 6, with an accent on 6.

CONSTRUCTION OF GUIDELINES

The first part of the study resulted in the publication of "Guidelines for sex equity aspects in textbooks". Some elements of it are described below.

After study of the problems connected with different subjects, it was concluded that there are some common rules for textbooks in all subjects. They regard text and illustrations.We have translated them in 'general guidelines for text and illustrations', valid for all subjects.

Apart from them, each school subject has its own characteristic male biases, which must be treated in a differential way. We have translated them in 'specific guidelines', of which those for physics and technology will be cited below, together with the general guidelines (the publication contained moreover guidelines for Dutch language, foreign languages and history).

General guidelines for the text

1. *The text must mention human beings*

Too often textbooks, especially those for science and technology, don't mention people at all. They only present abstract ideas or formulas.

2. *The text must mention men as well as women*

It is often presumed that descriptions of people concern both men and women. But it will often be necessary to mention the role of women explicitly. The text must not always use he, but can alternate, use plural, or rephrase the sentence.

3. *The text must mention women and men in activities both in the profession and at home*

Women must not only appear as housewife or mother. They also have to act in professional situations, and not only in the traditionally female professions.

The text must pay attention to occupational titles. The choice between using masculine and feminine forms, or between using masculine forms but considering them as sex neutral, is a difficult one.

The best solution would be to have sex neutral words. If we don't, our preference goes to using the 'masculine' forms but as generic, as long as the accent in the text is upon the function. Where individual persons are referred to, the feminine may remain necessary.

4. *The text must ascribe all qualities to both men and women*

Most cultures have stereotypic ideas about the qualities of women and men, ideas which may vary from culture to culture. For example: men are active, competitive, agressive, rational, technical. Women are passive, cooperative, peaceful, emotional, nurturing. But all these qualities can be met in both men and women, and that is what textbooks should describe.

5. *The text must mention women and men in equal positions and situations*

The text must not always show men in leading positions, men must not always be mentioned first (men and women, boys and girls). The qualities of women should not be valued less. Women should not be adressed by their first name in situations where men are not.

General guidelines for illustrations

These are parallel to those for the text:

1. *Illustrations must show human beings*
2. *Illustrations must show men as well as women*
3. *Illustrations must show women and men in activities both in the profession and at home*
4. *Illustrations must show both men and women with various qualities*
5. *Illustrations must show women and men in equal positions and situations*

Specific guidelines for physics

1. *Relation to daily life*

Physics textbooks must show a relation between physics and daily life, daily experience and the human need to explain surrounding phenomena. They must not deal only with abstract phenomena and theories. Examples must be taken from the daily life and experience, not only from industrial practice.

2. *Relation to society*

Physics textbooks must show a relation between physics and society. Physics is looking for answers to many questions of society. Think of: energy, environment, transport, arms.

It is important to pay attention to the positive aspects of physical knowledge, although this may lead to passing over in silence the negative or threatening aspects.

3. *Relation to professions*

Physics textbooks must show a relation to professions which require knowledge in physics. Women too must figure in scientific and technical careers.

4. *Relation to the human body*

Physics textbooks must pay attention to examples and phenomena that haven to do with the human body. The concept of energy can be explained from the balance of energy of the human body, for example.

5. *Relation to historical development*

Physics textbooks must pay attention to the history of science. It is not correct to present the actual body of knowledge in physics without mentioning the historical developments which have preceded.

Specific guidelines for technology

A new subject 'technology' is to be introduced in Dutch secondary education for all 12 to 16 years of age.

Technology too must pay attention to both technical principles and skills, as to the social aspects of technological developments.

1. *Applications of technics*

Textbooks for technology must show that diverse raw materials can be subjected to technique: wood, metal, plastic, textile.

2. *Sphere of life*

Textbooks for technology must not only take their examples from the sphere of life of men, but also from spheres interesting to both women and men.

3. *Relation to people*

Textbooks for technology must make clear that technology is an aspect of human activity, not an autonomous phenomenon from outside.

4. *Organisation of society*

Textbooks for technology must show the consequences of technological development for the organisation of society. These consequences can be both negative (loss of human lifes in dangerous work) and positive (reduction of working hours, schooling for all children).

5. *Social consequences*

Textbooks for technology must show the social consequences of technological developments, both positive (better health) and negative (arms race).

6. *Historical developments*

Textbooks for technology must show how technology has developed throughout history.

7. *Professional world*
Textbooks for technology must show that technical occupations can be held by both men and women.

The guidelines should serve two purposes:
- analysis of existing books,
- guidelines for new books.

As they are, they serve more the second purpose. If applied to existing textbooks, they will mainly show what we know already: the insuffuciency of those books in meeting the interests and needs of female students.

EVALUATION OF THE INSTRUMENT

After construction of the guidelines, an evaluation has been held among the target group: educational researchers, curriculum developers,text developers, counselors,teacher trainers, educational publishers; all those working to support the actual teachers. We have chosen them as our primary target, because their span of influence is broader than that of the individual teacher.

The evaluation investigated two questions:
- does the target group agree with the making of guidelines;
- does the target group agree with the guidelines in their actual form.

A survey was held with a written questionnaire (anonymous). It contained 109 items to be answered on a 5-point scale (agree-not agree): questions concerning the actual guidelines; and a number of open ended questions, where people could be more specific either with criticism or with additionel suggestions. The overall response percentage was 35%, 50% of them women, 50% men.

As for their opinion on making guidelines, the overall majority was highly positive (table 1).

Table 1 Mean scores of women and men on questions about the importance of (guidelines for) sex equity in textbooks (maximum score = 5; last score is negative!).

	women	**men**
I think it is important to make guidelines	4,7	4,4
textbooks should not contain text and illustrations with only traditional sexroles	4,6	4,6
the present guidelines are useful instruments to evaluate textbooks	4,2	3,8
publishers should improve their textbooks	4,6	4,3
sex equity aspects must play a role in the choice of textbooks	4,5	4,2
it is superfluous to pay such attention	1,4	1,7

As for the specific guidelines, we have asked opinions of respondents on all the physics and technology items separately.

Table 2 Mean scores of opinions of women and men concerning the specific guidelines for physics (maximum score = 5).

	women	**men**
Physics textbooks must show relation to:		
daily life	4,7	4,5
society	4,6	4,4
scientific professions	4,6	4,0
human body	4,4	4,0
historical development	4,4	4,0

Table 3 Mean scores of opinions of women and men concerning the specific guidelines for technology textbooks (maximum score = 5).

	women	**men**
Technology textbooks must show a relation to:		
applications of technics	4,6	3,7
sphere of life of men and women	4,8	4,6
human activity	4,9	4,6
organisation of society	4,8	4,6
social consequences	4,8	4,5
historical developments	4,5	3,9
technical occupations	4,8	4,3

As mentioned before, respondents could express themselves in open questions.

For physics, several respondents thought the quidelines were still too general. Several problems could be solved just by teaching practice. Points missing: the emotional aspect, the fun of doing physics, more practical experiences, more from concrete to abstract in stead of too much abstract teaching, explicite norms and values, a critical analysis of the role of physics in society (e.g. arms industry).

Some comments for technology:

Guidelines are more ideological than practical; guidelines are premature, because there is no explicite philosophy on women in technical education; more hands on training.

COMMENTS

A response percentage of 35% is not very high. The questionnaire was filled in mainly by those sympathetic towards sex equity (as appears from the high scores in table 1). Some respondents were extremely negative (for religious reasons, as appears from their comments).

That people who feel sympathetic (or at least concerned) are the different target groups is not known exactly, but ranges, by estimation, from 10 to 25%.

A "hidden agenda" of our questionnaire is to stimulate the discussion on the content of physics and technology education. This aim, although not evaluated systematically, must not have been reached everywhere: many of the institutes gave the questionnaire to those already interested (which appeared from comments on the questionnaire or in accompanying letters). The questionnaire showed that 26% were involved in sex equity projects, 74% were not.

The responses and comments, allow some minor changes in the text of the guidelines. However, no item was explicitly rejected. (Most of the negative criticism went to two general chapters in the guidelines on women and education and women and labour, not dealt with in this article).

CONCLUSIONS

We can say from this evaluation that the respondents attributed high importance to paying attention to sex equity aspects in textbooks and to making guidelines for this purpose.

The actual guidelines were generally accepted.

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EVALUATION OF A PROJECT DESIGNED TO ENCOURAGE GIRLS TO TAKE UP TECHNICAL OPTIONS IN RURAL SCHOOLS

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Abstract:

The paper reports on the evaluation of 'Futura Girls', an initiative in a rural area of England, designed to encourage girls towards technology. Implicit assumptions on the part of course planners revealed a 'deficit' perception of girls as technically less competent than boys. However, some course tutors revised their estimation of girls' skills, and the experience may have had a positive effect on tutors' and teachers' views about equal opportunities.

Since the implementation of the Sex Discrimination Act in 1975, schools and other educational establishments in the UK have been required by law to give pupils of both sexes equal access to all subjects offered. However, ten years later, an almost complete division by sex is still apparent in crafts subjects after the second or third year of secondary schooling; in 1984, 96% of 'O' level entrants for Cookery were girls, and 94% of entrants for Technical Drawing were boys. In certain other subjects the pattern is even more extreme; 99.7% of entrants for Neddlework were girls and 97.7% of entrants for Woodwork were boys in 1984.

Recent moves to a revised craft, design and technology curriculum are important in two ways; first, the 'new' CDT, with is emphasis on the study of a variety of materials, on problem solving and on control technology makes it potentially a subject of greater value to girls than the old trades-dominated subjects of woodwork and metalwork. Secondly, the new CDT has the potential, unlike the former curriculum, to involve and interest schoolgirls as much as boys. For these reasons the continuing absence of girls from CDT represents a lost educational opportunity.

In March 1983, and the succeeding three years to 1986, a rural LEA mounted a week long technology 'experience' for girls facing the choice of technical or other crafts at the end of their third year of secondary school. An evaluation was mounted of the attitudes and responses of craft teachers in the contributing schools in 1986, when the project had run for four consecutive years.

Two recent surveys of teacher attitudes to girls and technology indicate that teachers of both technical and domestic crafts are among those least in favour of equal opportunities (see Pratt, 1985; Spear, 1985). This is clearly a barrier to girls' uptake of technical subjects when they become optional at school. It was decided to interview all the course tutors named (5 individuals) and a stratified sample of 5 heads of department and 10 staff from fifteen of the schools. (See Appendix I)

Interviewees are referred to in the text by numbered references, eg (14). Brief details of each individual interviewed are listed in Appendix II. Any more detailed information would make it possible to identify individuals.

The girls' response

Without exception, respondents thought the girls had enjoyed the course, and seventeen of the teachers interviewed expressed themselves as pleased, delighted or thrilled with the effect on the girls. The dissenters were disappointed by aspects of the teaching approach (see below) or because the course did not seem to have led to greater take-up of CDT by girls in their school. Some indicated that the positive effects were immediate rather than long lasting (14; 19) and one suggested it was all a nine day wonder with the girls being "in the limelight" for a bit (2).

It is interesting that five men were named as course tutors, although it turned out from the interviews that two other CDT teachers, both women, had been involved inall or most of the five courses. They were presumably seen as assisting in sessions, and the course tutors defined as those who led the four areas of the course.

A secondary purpose of the course was to encourage girls to think about careers or jobs requiring a technical qualification. Respondents were generally agreed about the serious lack of employment for young people in the area; most described town in particular as being 'pretty grim', and the prospects very low, two teachers independently mentioning a figure of only 8% of town schoolleavers obtaining employment. Agriculture was a diminishing source of employment, and the major local firms took few or no apprentices. A number of small builders' merchants offered manual labour for boys. Various light industries and new companies, including Japanese were moving in. Some saw this as increasing opportunities, though one tutor who had visited a high tech Japanese company said he has been told they were looking for unskilled or semi-skilled labour, not technically qualified people.

Very few of the teachers had had such direct contact with industry; this may be a reflection of the fact that according to several respondents, well over 70% of their 16 year old school leavers went straight on to YTS courses, while the brighter ones went on to college. The YTS buffer may actually be hindering even teachers who have formerly been close to industry, from maintaining their local contacts in a way which would help them find jobs or openings for their pupils:

> "I think a lot of teachers quite honestly are unaware now and feel less qualified to comment on job opportunities.....years ago..... I used to feel I was pretty much in touch with what employers are after..... I'm not so sure any longer" (12)

This pattern is an especially worrying one to find among craft teachers, many of whom have worked for several years in industry before they came into teaching.

The competence of girls in CDT

Two tutors did not seem at the outset to have taken very seriously the idea that girls might be competent at crafts; one admitted he saw the course as an opportunity for him to play with technical equipment, (17) and another that in the first year (though not subsequently) he looked on Futura Girls as a 'gimmick' (15).

The course tutors nearly all mentioned that the girls had been surprised and impressed by what they could achieve in a relatively short time. The intensity of the course was an important feature as far as the organizers were concerned; it was in effect a crash course in CDT with the girls taken rapidly through a number of processes including the use of compuuterized lathes. However in the desire to ensure that girls experienced immediate success in producing impressive artefacts, some equally desirable principles of CDT taching may have had to be sacrificed.

One course tutor (15) admitted that the girls were not really allowed much free expression, "I don't think they had very much free learning, free expression ... it was a matter of get on with it, this is the way we do it ....." and implied that normally in the teaching of electronics (that is, to boys), the pupils would work out circuits for themselves, an element that was skimped for the Futura Girls : "the circuit was worked out for them, it was merely a means of getting the thing together."

Another course tutor had already identified the need for a different approach more in line with current thinking:

> "I would like to see an actual technology section brought into the course itself; it would be interesting to see the girls given one day to solve a problem ..... something like a mini-egg race sort of thing, where they're given a pile of materials, a problem, and they're given a limited amount of time to work it, so that it's an actual brainstorm rather than .... and that would, I think, be very productive (7)

Teachers' and course tutors' positive views of girls' competence

A positive effect of the course was the craft teachers' enhanced appreciation of girls' ability to do their subject well. It showed up most in the answers to some statements which had also been posed to the samples of teachers studied by Spear and Pratt.

Respondents were asked to give their views on a number of statements about equal opportunities. In order to be able to make some sort of comparison between the teachers in these studies, and the sample of craft teachers, ten questions which had been posed to the larger samples were also put to the rural teachers.

It is important to remember that the number of rural teachers is very small : only 20, so that too great reliance should not be placed on the meaning of the percentages in the tables below: for example, 5% represents only one response, 60% only 12, etc. Relevant sample numbers therefore appear in each table. The context of the responses should also be considered. Both the national and regional samples consisted of responses to postal questionnaires, while the rural teachers faced a female interviewer. It is possible that this accounts in whole or in part for their significantly more favourable response to certain questions.

The largest difference between these teachers and others in a regional sample was in the response to the statement

i 'Women are as good as men at complicated technical matters'

	Strongly Disagree %	Mildly Disagree %	Mildly Agree %	Strongly Agree %
i Rural (N=20)	5	15	20	60
Regional (N=45)	2	47	24	27

(Significant difference at 0.01 level)

Sixty per cent strongly agreed they were, compared with only 27% of teachers in a regional sample. It may be that one of the most powerful effects of the Futura Girls programme was to convince teachers that girls possess just as much ability as boys in the technical sphere. Several teachers spontaneously offered remarks which would support this interpretation.

For instance, after talking about employer prejudice against women, an older teacher said most firmly "Nevertheless, I think they can do the job, I'm certain they can do the job" (15). And another teacher said that COT staff now viewed their Futura Girls as 'professional' and 'one of us' ( )

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Some teachers also remarked that when the girls' work was displayed to the rest of the third years, boys in particular had been impressed and 'surprised' by the quality of work produced.

Changes in teacher attitudes

Two previous studies of teacher attitudes to gender equality (Pratt, 1985; Spear, 1985) indicate that

(i) teachers share a predisposition to agree with broad general statements about sex equality, but are more doubtful about making specific efforts within their own classrooms

(ii) craft teachers, along with teachers of domestic subjects, physical science and maths, seem to be less in favour of promoting gender equality than other groups of teachers

(iii) science teachers do not consider that girls need to acquire technical competence as part of their education, and they

(iv) regard a woman's career as less important than a man's, and women's sphere as essentially domestic.

(v) In addition, both Pratt (1985), and another national study by Kelly (1985) found women teachers more favourable towards equal opportunities than men, a factor modified by subject taught, and London teachers more favourable than those in the rest of the country.

Both the national and regional samples included teachers of both sexes and most secondary school subjects. As the rural group are all male, with one exception, and all craft teachers, one might have expected their attitudes to gender equality to be less favourable, not more. The pattern of difference between rural teachers and others is also what one might expect as an effect of the Futura Girls Intervention. They gave similar responses to general questions about gender equality, and like the national sample investigated by Pratt, were less likely to give strong agreement to statements implying positive activity towards gender equality in their own classrooms. The significant differences are in the two linked issues of girls' technical education and the work that girls and women can do. These support the tenor of the rest of the interview responses, that rural teachers had become more aware of gender inequalities in the craft area.

(Due to considerations of space this paper reports on some not all of the pattern of findings).

The rural sample of teachers was significantly more prepared to encourage equal opportunities against parental oppostion : 85% strongly agreed with this statement compared with only 51% of the other teachers. This reaction may be a function of the way craft teachers perceive parents' poor image of their subject, an attitude they already have to challenge.

d Teachers should encourage equal opportunities even when there is no parental support for this policy.

	%	%	%	%	%
d Rural (N= 20)	0	0	-	15	85
National (N=847)	1	2	8	35	51

(Significant at 0,05 level)

Spear's sample of science and other teachers revealed considerable bias in their theoretical view about the relative value of technical education for girls and for boys. Spear asked her respondents to indicate the importance of technical subjects to male and female pupils on a four point scale of importance. The rural teachers were asked to agree or disagree on a four point scale with the statement that "Technical education is very important for girls'/boys' education" (the two questions separated by five other statements for consideration).

	Strongly Disagree	Mildly Disagree	Mildly Agree	Strongly Agree	
	%	%	%	%	
b Technical education is very important for girls' education					
b Rural (N= 20)	0	5	20	75	for girls
Regional (N= 67)	1	30	45	24	for girls
(Significant at 0,01 level)					
b Technical education is very important for boys' education					
Rural (N=20)	1	0	30	65	for boys
Regional (N=67)	0	1	49	49	for boys
	Not at all	Not very	Fairly	Very	
(Not significant)					

The fact that there was no significant difference between rural teachers' response to the question about boys' technical education, while there was a significantly more positive view of its value for girls than among other teachers strongly suggests both that the set of questions and their response had some sort of validity, and that rural teachers really did take a different view.

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The role of women

All but two of the rural teachers rejected the proposition that 'A woman's career is not as important as a man's, compared with less than half the sample of science teachers.

	Strongly Disagree	Mildly Disagree	Mildly Agree	Strongly Agree
e Rural	90	5	5	0
Regional (N= 45)	42	16	37	7

(Significant at 0.01 level)

Clearly, the idea that a woman should have a 'career' is closely connected with the question of how she deals with the issue of childcare. If one takes the view that care of young children is women's responsibility, this will have an effect on one's views about women and work. The majority of Spear's science teachers, 73%, agreed that women should give up work to look after their children until they were old enough to go to school. Only 7% strongly disagreed. In contrast, the rural teachers were quite evenly divided on the question, and 30% actually voiced strong disagreement with this conventional assumption. The difference approached, but did not reach significance.

Women should only have children if they are prepared to give up their jobs to look after them until they are old enough to go to school.

	Strongly Disagree	Mildly Disagree	Mildly Agree	Strongly Agree
j Rural	30	20	10	40
Regional (N=45)	7	22	27	44

(Not significant)

(See 'Statistical Note', Appendix 1)

Interestingly, none of the tutors mentioned specifically encouraging girls to take craft subjects, or to think about technical occupations. The hope seemed to be that the good experience of the course would rub off and have these effects indirectly. The one comment about girls' reaction to women visitors also suggests that careers education was not perceived by them as an essential feature of the course. The unwillingness of tutors to be explicit in talking to the girls about what it was hoped would happen as a result of the course reflects the reluctance of GIST teachers to be explicitly 'propagandistic' about scientific and technical career choices for girls (see Whyte, 1986).

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Appendix 1

Details of teachers interviewed

Twenty two teachers were interviewed, and are referred in the text to by numbers 1-22. They fell into four categories, some overlapping:

Named as course tutors : Numbers 1: 7: 12: 15: 17: 20 (i.e. seven in all)

Heads of Craft/CDT Department : Numbers 1: 4: 6: 8: 11: 12: 16: 18: 19 (i.e. nine in all)

Staff with senior management or other departmental head responsibility : Numbers 2: 9: 15: 20: 21 (i.e. five in all)

Craft teachers (i.e. not HoDs, not with other senior management responsibility): Numbers 3: 5: 7: 10: 13: 14: 22 (i.e. seven in all)

Appendix 2

Comparison of samples

As Pratt's national sample consisted of over 900 teachers, the rural teachers were regarded as a subsample of the same population. The expected numbers of rural teachers in each of the four categories were therefore estimated by computing the numbers of teachers in Pratt's five categories, reallocating half each to the 'mildly agree/disagree columns'. Then a chi square test was applied. The chi square value is given for each of these items, together with the value (in brackets) that would have to be reached for a significance level at 0.05 or 0.01 respectively).

a The educational system treats girls less favourably than boys

x = 3.38: Not significant (7.81 @ 0.05)

d Teachers should encourage equal opportunities even when there is no parental support for this policy

x = 9.03: Significant at 0.05 level (7.81)

f It would be a good thing if pupils did not regard certain subjects as 'girls' subjects' and others as 'boys' subjects'

x = 5.88 Not significant (7.81)

g Schools should set an example in reducing sex discrimination

x = 4.83: Not significant (7.81)

k I am particularly interested in encouraging equality between the sexes in my teaching

x = 5.23: Not significant (7.81)

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As Spear's regional samples were rather small, 45 and 65 respectively, contingency tables were drawn, and chi square values computed :

b Technical education is very important for girls' education

x = 17.23 : Significant at 0.01 level (11.34)

e A woman's career is not as important as a man's

x = 16.89: Significant at 0.01 level (11.34)

h Technical education is very important for boys' education

x = 5.8 : Not significant (7.81 @ 0.05 level)

i Women are as good as men at complicated technical matters

x = 51.57: Significant at 0.01 level (11.34)

j Women should only have children if they are prepared to give up their jobs to look after them until they are old enough to go to school

x = 7.22 Not significant (7.81 at 0.05 level)

CHINESE WOMEN RISE WITH FORCE AND SPIRIT IN SCIENCE AND EDUCATION

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Women oppressed by feudalism in the old China

In the poor and backward old China, the massed of women led a more miserable life than men. Throughout China's feudal society, which lasted for more than 2000 years, deep-rooted feudal ethics existed, the women were oppressed at the bottom by the ignorant and backward feudal ideology. The feudal ethical code and backward customs acted as an invisible rope tightly binding the women's hands and feet. For example, the women had been physically injured and mentally afflicted since their childhood, and the possibilities that they could take part in public activities were very limited. The foot-binding prevailed as a corrupt custom. And at that time, many families which could not bring up their children sold their own daughters to rich families as child daughters-in-law. In fact, they became child labourers and did the heavy work that they were unable to stand and often got scolded and thrashed for no reason at all. In cities, some women were driven to become streetwalkers by cold and hunger. As for the girls of the large families, they could not step over the thresholds and see anybody freely. They didn't enjoy real personal freedom and the freedom to choose their own husbands and had to obey orders from their parents and the woman matchmakers unconditionally, despite the fact that they could gat enough food and clothes. They became

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belongings or toys of their husbands after they got married.

Every woman was bound by the feudal doctrines such as the "three obediences" (i.e. obedience to her father before marriage, to her husband after marriage, and to her son after the death of her husband) and the "four virtues" (morality, proper speech, modest manner and diligent work), and could get neither freedom of activities nor rights and opportunities to be educated. A few women had little opportunities to get jobs after their graduation, though could go to school to study. So the women's level of education was much lower than men, and could not live independently, but had to completely depend on their husbands. This not only led to their low social status, but also deprived their equal right and status even in their own families.

New Chinese women's contribution to science, technology and education

After liberation, the Chinese women appeared with a completely new spirit. In 1954, New China's first Constitution stipulated that women be given equal rights in politics, economy, culture, and in social and family life. The women standed up and smashed the spiritual shackles. They came out of the four walls of a family and plunged themselves into the powerful current of social movement.

Shortly after the founding of New China, there were 600,000 women employed throughout the country, consisting of 7.5 percent of the total work force at that time. In more than 30 years that follows, especially in recent years, the women's qualities have been improved along with the development of social economy, the rise of the people's living standards and the gradual spread of education. Therefore, the women both in towns and in the countrysides have more and more opportunities to work and take part in social activities, their fields of activity have kept expanding. According to statistics, the present number of working women has increased to 43.24 million, consisting of 36.4 percent of the nation's total work force, or 71 times more than that 36 years ago. Not only the quantity of working women have greatly increased, but they also make great contribution in all trades and professions with a high sense of responsibility of being the master of the nation, and so do women who fight for the cause of science and education.

In the early days after the founding of our country, woman scientists were very scarce. After more than 30 years, the number of women engaging in scientific research have risen greatly. According to statistics, today Chinese woman scientists have increased to 2,396,000, consisting of one third of the total number of scientists and technicians. Among them,about 58,000 are engineers and technicians, 65,000 are agricultural technicians, 1,246,000 health technicians, 96,000 scientific researchers and 410,000 teachers. Up to now, 14 Chinese woman scientists have received their doctorate degrees since 1981, the year China reintroduced the title. More than 3,500 women have received master's degrees since 1979, consisting of one twelfth of the master's degree receivers. Some woman scientists have achieved excellent successes while they studied and worked abroad. They apply scientific results to the enhancement of the research and teaching after they return to the country. Some women have already became respected specialists.

Let's take women who work at the Chinese Academy of Sciences as an example. It is well-known that the Chinese Acacemy of Sciences is the highest academic institution and a comprehen-

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sive research center of natural sciences in China. The academic members of different Divisions of Chinese Academy of Sciences are selected from those scientists, proffessors and engineers with high academic level and distinctive contributions. Some of them are women. They also have won this highest honourary title in scientific community. It also should be mentioned that all these woman members hold several other posts simultaneously. They teach while doing scientific research, they direct master and doctor candidates while undertaking heavy tasks to train young scientists.

For example, Dr. Gao Xiaoxia, a member of the Division of Chemistry, is a famous analytic chemist in China and a professor at Chemical Department of the Beijing University. She not only has made many creative research work in the field of electroanalytic chemistry, especially in the theory and application of polarographic catalytic waves, but also directs and works together with numerous postgraduates to explore a new field that has been hardly done both at home and abroad, i.e. electro-analytic chemistry of rare-earth elements, and has got breakthrough results. As another example, Dr. Lin Lanying, a member of the Division of Technological Sciences, has devoted herself to the study of semiconducting materials physics for a long time. The development of semiconductor devices and the appearance of semiconducting materials are closely connected with her active organizational work and directions from the very beginning. Dr. Xie Xide is a member of the Division of Mathematics and Physics and has made a series of opening works on semiconductor physics in China. She contributed a lot in setting up the research offices and an institution and is a professor and vice-president of the Fudan University in Shanghai, actively training the young people in solid state physics. Research fellow Ye Shuhua is the head of Shanghai Observatory, who is engaged in the exact determination of universal time and the research on the rotation of the earth and the drifting of terrestrial poles. She led the scientific research personnel to set up independently a comprehensive universal time system with high precision, thus making China the most advanced internationally in the measurement precision of the universal time since 1963.

These women scientists not only have made important contributions to research and education but also are active in social activities. They are leaders of some societies and are selected as the members of national leading organizations at various levels. For example, Lin Lanying is a director member of the Electronic Society and Electronic Material Society, vice-chairman of the Chinese Association of Science and was a delegate of the Third, Fourth and Fifth National People's Congress and a member of the Standing Committee of the Third National People's Congress. Xie Xide is a member of the Presidium of Chinese Academy of Sciences, the deputy head of the council of Physical Society of China and the member of the Executive Committee of the All-China Women's Federation. Cao Xiaoxia is not only a member of the council of Chemical Society of China but also a member of the Fifth All-China Political Consultative Conference.

Besides women of Chinese Academy of Sciences , women who work at other departments of science and technology have also made many successes and contributions to the socialist modernization construction.

For example, the first doctor of electronics of new China, Wei Yu, is the vice-president of the Nanjing Engineering

Institute and the leader of the Department of Biomedical Engineering and the head of the Institute of Radio-Electronics. She got a Ph. D. with "the best" academic record at the Aachen Technical University , the FRG, in only one year and a half. After returning to China, she has made great contribution to the field of biomedical electronics. The woman medical scientist Xiu Ruijuan made a brilliant contribution to medical science, and has got many breakthroughs in the field of micro-circulation, thus shocking the international medical circles.

The similar examples are too numerous to mention. All these fully show that the Chinese women have inherited the valiant and industrious tradition of the Chinese people, and that women are by no means inferior to men in wisdom and ability. Women have become an important force in the socialist modernization drive.

Therefore, many advanced women and woman's collectives are commended by the state on March 8 every year. For example, the All-China Women's Federation held a meeting for commemoration and commendation in 1985 and many advanced women were highly praised by leaders of the state and various departments. Last year, 1,928 women were chosen as the "March 8 red-banner pacesetters" and 228 as "March 8 red-banner groups" in Shanghai city alone. On the International Working Women's Day this year, the advanced woman delegates from 14 provinces, cities and autonomous regions came to Beijing and held meetings, reporting their new achievements, thus stimulating more enthusiasm from the masses of women.

Although socialism has poened up a broad and good prospect for Chinese women, the problem of allowing women to share equal rights and status in all fields is far from being resolved due to the influence of feudal ideas lasting for more than 2000 years. It is an important fact that as a whole the scientific and cultural cultivation of Chinese women is still very low. According to statistics, illiterate women are about 70 percent of all illiterate people of the country.

In the science and technology fields, the ratio of China's men to women is 2.1:1: while the ratio between those men and women who have acquired the title equivalent to an engineer (a middle academic title) is 4.4:1, and that between those men and women who have acquired the title equivalent to senior engineers (a high title) is 7.6:1.

There are still more facts. For example, the Constitution and laws ensure the equality between the sexes and freedom of marriage, but the phenomena of mercenary and arranged marriage have still existed. Some factories and schools don't carry out the principle of equal chances without sex discrimination when they enrol new workers and students. Some factories think that women have many housework and their pregnancies and maternity leaves interfere with their work, so don't want to employ them. Some sections discriminate against women in promoting personel and allotting dwelling houses, etc. In addition, in the families some men do not do any housework due to the feudal thoughts, while most or even all housework are done by women. Such practices divert the women's attention on work and study. Moreover, the birth control is obstructed and disturbed by the feudal idea of regarding men as superior to women in different parts of society.

To ensure women's complete and thorough liberation, it must be done forst to speed up social progress. Only when politics, economy, culture and ethics, science and technology are developing at a high speed, a full and sound condition for the women's liberation be created. On the other hand, women should exert in the struggle for self-liberation and wage indomitable and unremitting struggle against traditional feudal thought continuously and at a large scale. At the same time, women should actively improve their own quality and ability to prove with remarkable successes that women can also make greater contributions to the development of the country and even of the mankind.

The Half Sky---Woman Scientists in Our Institute

Jinpei Zhang

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In China people say that women are the half sky. But before 1949 there was no such saying. Women seldom had the opportunity to get job and salary. They were in a poor position both in the society and the family. They had to depend upon their husbands in money and their routine jobs were cooking, washing and raising children. Most of them ran around the stoves for the whole life.

Since the founding of new China the position of Chinese women has been raised gradually. Women have got equal rights of being educated and getting a job. As China adopt the policy of " paying the same to the same job ", women get almost all kinds of jobs and earn as much salary as men. They no longer dependent on their husbands in money, so they have the same authority in their family affairs. In many families actually wives make decision. This phenomenon is humorously called " qi-guan-yan ", which means tracheitis and is the homophone of the hen-pecked in Chinese. For most families in the city man and wife both go to work and, when coming off work, do household chores together.

In science and technology, like in any other areas, there are numerous women doing various work. Many woman scientists are talent and famous. Here I only give a brief account of the woman scientists working in our institute and hope that readers can get a full view from a very small corner.

The Institute of Elemento-Organic Chemistry of Nankai University, founded in 1962, is one of the largest institutes belonging to universities. The main task of the institute is doing theoretical and practical research in pesticides chemistry, organo-metallic and organic compounds containing non-carbon elements such as silicon, phosphorus, etc. (according to the Russian terminology convention those compounds together are called elemento-organic compounds). The institute has published many research papers and completed a lot of projects since the founding, therefore gained certain fame both in China and abroad. In addition to research there are also teachings, especially for graduate students, so researchers here, like in other departments, are teachers too (professors, associate professors, lecturers and TA).

Let us first have a look at some statistics. There are 72 woman workers among the total 173, making up 41.6%, 2 woman professors (50% of all 4 professors), 11 woman associate professors (33%), 23 woman lecturers (45%).

Woman scientists have contributed greatly not only in research and teaching, and also in the administration. Professor Ruyu Chen, former director, was in charge of the institute for 4 years. Now there are one director and two deputy directors, one of whom is a lady, associate professor Jin. Ten research group heads are ladies. From these figures, therefore, it is not an exaggeration that women in our institute do deserve the population of " the half sky ".

While women enjoy the right of working, sometimes they complain of not having enough time for relaxation and that the burden of household chores is rather heavy. During weekend (only one day) they have a lot of things to do : washing, cleaning, shopping and cooking, etc.

In order to let the readers know some details I have interviewed several ladies of our institute and presented the talkings as follows.

Professor Xukun Wang is a charming lady, the head of a research divesion. I had a talk with her. When asked questions she was willing to answer.

Question 1 : People in our institute say that you are the strong woman in the institute. What's your opinion ?

Answer : I don't think I deserve the title. All women in our institute are strong, but everyone is in different period of time. For example, professor Chen is older than I. She has done great contributions. As I am older than most women here, now it is the time of my generation. Several years later someone from younger generation will be in my position. I am lucky enough to have the same opportunities as man in education and job, I should appreciate it and do my contribution to the society. I think we women cannot rely upon our husbands and must be independent both in doing and thinking. For this we have to work hard and this is the difference between our Chinese women and some American women.

Question 2 : How do you think of the policy of opening and reform ?

Answer : Excellent ! The achievement from this policy is great and well known. I tell you a story. In 1974, when the American ping-pang team was visiting China, a female ping-pang player of the team said that Chinese living standard was so low that she couldn't live in China. At that time I couldn't understand her. I thought, we had food to eat and clothes to wear, what's wrong with us ? Four years later I went to America and then I understood her. You see getting together promotes mutual understanding. I realized that no matter what system they are from, people have many things in common. Opening the door makes people all over the world together. On the other hand opening policy changed the leader's view and made them adopt reasonable policies.

Question 3 : How do you require your graduate students ?

Answer : I think I should have an equal attitude towards my students and take democratic ways to deal with them. Graduate students have got certain fundamental knowledge and ability of independent work, so I should let them do things in their own way and not force them to take my way. However I should give them guidance. Some graduate students have some weaknesses, e.g. having rather narrow knowledge, not creative enough and not very good in doing experiment, etc. I must teach them to widen their knowledge and to improve their experiment skills. But I feel that it's not an easy task to make qualified graduate students.

Question 4 : How do you use your holidays ?

Answer : We get a winter vacation, a summer vacation and holidays for national day, spring festival etc. in a year besides weekend. Since I came back from the U.S. in 1981, I haven't spent one vacation for rest. I used most vacations for preparing new courses and writing papers except one summer in 1985, when I went to Japan to attend an international conference, that, in my opinion, was also a good rest. I find that during vacation one can be very efficient in writing as you don't have any psychological burden.

As for other holidays, we spend all of them for eating (buying food and cooking). (Ask : Have you ever thought of traveling with your family in vacation ?) Yes, I have planned many times, but haven't got time, always busy. I haven't climbed any famous mountains of China. I am going to climb the Yellow Mountain in the next summer, but not with my husband. He walks too fast for me to follow and he rides bike too fast too. I feel that I always in a status of catching up with him in my life. Maybe I will bring my little son to the mountain.

Question 5 : How do you share household duties with your husband ?

Answer : We have a best mutual understanding in this. Our principle is to keep household chores as simple as possible. My husband, Zhu, is a professor in chemistry department, so we don't have much time to do household chores. We eat simpler lunch and dinner than ordinary family. Sometimes Zhu complains : " Look at other families !". Usually Zhu prepare lunch and I do dinner with my son, because dinner is more complicated than lunch. During preparing time I can have a chat with my son. We have two sons, the older one is studying at Brigham Young University in the U.S. and the younger one is in middle school. I should thank my parents and Zhu's parents. They took care of our children when they were little boys.

Question 6 : What do you like most and what do you dislike most ?

Answer : What I like most is books. My family has the tradition. My grandfather was an intellectual of feudalism. He had a title called " ba-gong ". My father was an engineer. When I was young there were a lot of various books in my family. I was very fond of reading books, various books, that gave me many many things. Now my sons have got the same habit. I know that the knowledge only from book is not sufficient, and there are other things from life I should learn.

As for what I dislike, nothing. I like life which is colorful. I would try everything if I had time. I even thought of doing business or running a restaurant to provide first class service. I like chat with close friends, etc.

Another lady I interviewed is Mingde Wang, a lecturer. She was graduated from chemistry department of Nankai University in 1968 and sent to work in the countryside right away. In 1978 she managed to pass the exam and came back as a graduate student. Three years later she got her Master degree and has been employed in the institute since then.

Question 1 : How do you treat the relationship between work and study and between work and household chores ?

Answer : I do my best to complete my work but I am not very fond of my present work. I like to engage in advanced studies and hoped to be erudite. I think household chores are a complement to the work. Sometimes you can get pleasure from doing household chores. I hope to be excellent in both.

Question 2 : Can you say something about your husband ?

Answer : When young we fell in love at first sight, but later found that we were different in character, interest and hobby. For example, I like music while he likes Peking opera; I am talkative while he is reticent; I am an extrovert while he is an introvert; I am from south while he is from north, etc. I want him to be too good and he is careless about me. But in ordinary family life we help each other and live together peacefully. My only daughter is a strong tie between us.

Question 3 : How do you spend your holidays ?

Answer : I wish I could make best use of them in rest and getting pleasure, but at present conditions I stay at home with my husband and daughter in most holidays, talking, cooking and eating, watching TV and enjoying the pleasure of a well-off family.

Question 4 : What's your goal of pursuit ?

Answer : " God make me who should be of certain value ". I hope to make my contribution to mankind and to be an important person both to the society and to my family.

Question 5 : What do you like most and what do you dislike most ?

Answer : I like honesty and I think it's a pleasure to talk with honest friends. I dislike lies and detest those who don't respect my personality. If what I have to do doesn't agree with what I am fond of or I am misunderstood, I will be vexed very much.

Guiyu Jin is a deputy director of the institute and an associate professor. She is one of a few capable ones here and is remarkable in managing the institute, guiding her graduate students (total 4) and doing household chores. She was graduated from Dresden Technical University in east Germany. Like most Chinese women she is modest. When asked how she has managed to be able to do all these, she said :

I cannot say I am doing these things very well. I think there are two standards to measure one's work : higher standard and lower standard. When I use the lower one I feel O.K. about my work, but when I use the higher one I am not satisfied with what I have done. As you have mentioned, my responsibility covers three things, but my main energy is concentrated on the administration. I admit that it's not an easy job. I have to help the director to find projects, seek funding and coordinate the work of different research groups. In addition I also give a big part of my time to solve contradictions among persons or to ease quarrels if happened. These, I think, are not faced by research heads in the west.

At home I do most household chores because my husband, Zhang, works in an office outside the campus. Usually he comes home later than I, so I do most cooking. Of course sometimes he does too. Now the situation in the market is much better, you don't have to stand in a queue to buy food. Therefore I don't consider to prepare meals a big burden. Besides in sunday afternoon a servant girl comes to do the washing.

"RADICAL FEMINIST ANALYSIS" AND GASAT: SOME POSSIBLE CONFLICTS?

Ann Hibner Koblitz

Wellesley College

SOME QUOTATIONS:

"I am come in very truth leading you to Nature with all her children to bind her to your service and make her your slave." --Francis Bacon

"This vision of a new science fit well into the social and political order that was emerging in 17th-century England. In sympathy with an increasing polarization between masculine and feminine, public and private, work and home, the rhetoric of modern science pitted mind against nature, reason against feeling, objective against subjective." --Evelyn Fox Keller

"Just as surely as inauthenticity is the cost a woman suffers by joining men in misogynist jokes, so it is, equally, the cost suffered by a woman who identifies with an image of the scientist modeled on the patriarchal husband. Only if she undergoes a radical disidentification from self can she share masculine pleasure in mastering a nature cast in the image of woman as passive, inert, and blind." --Evelyn Fox Keller

"To strive to do valuable work as a female scientist is to strive for access to a part of society that embodies the quintessential values of patriarchal culture. The very word *science* implies masculinity.... [T]he predominant image of the scientist is as a solitary creator with a competitive spirit that pervades his feelings about his peers..." --Leanna Standish

"I think that my own conscious decision against a career in science was made when I discovered that the initiation rite required for admission to high school science courses was the cold-blooded murder of a frog." --Barbara Dodds Stanford

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SOME CURIOUS FACTS:

--The first three women to teach at the university level in modern Europe were in the sciences.

--The first women to obtain doctorates (in the modern sense) were in the physical sciences, anatomy, physiology, zoology.

--The first and second women to hold chairs at research universities in Europe were in mathematical physics and physical chemistry.

--Of the first degrees granted to women at Geneva University 1876 to 1883, there were 35 in the natural sciences, 31 in medicine, and only one in letters.

--An 1897 survey of the German professoriate asking whether women should be admitted to institutions of higher education revealed that the mathematicians were unanimously in favor of women's admission, while historians were almost unanimously opposed.

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In attempting to present an 8-page version of what is, at the moment, a 50-page book outline, one runs into almost insurmountable problems. I have opted to cope with these by giving the above selection of quotations and facts. Hopefully, these will serve as an impressionistic introduction to issues of gender and science as analyzed by so-called "radical feminist" theorists and others who write on the topic.[1]

There is a spectrum of views represented by these writers. They are not always consistent, and they vary widely in their degree of sophistication and level of analysis. But in its most general guise, though, the new set of theories says that centuries of male domination of science have affected its content-- what questions are asked and what answers are found. "Science" and "objectivity" have become inextricably linked to concepts and ideologies of masculinity, in the eyes of these writers. Some suggest, following Nancy Chodorow and others, that only men-- and women who try to be like men-- can be objective, because objectivity implies dissociation from the female, or "first caretaker" (i.e., mother).[2] Women are thus "relational," "nurturing," "subjective." As Leanna Standish says: "It seems clear that the male world of science and technology is not conducive to the intellectual, emotional, or instrumental development of women. We must not be afraid to say that we are psychologically starving here."[1]

The radical feminists argue that women must produce a female science, or a "feminist science," which will be liberated from the straightjacket of objectivity, masculinity, and domination in which "male science" has been confined since the time of the Scientific Revolution. Science should be put into the "relational hands of women," to quote again from Standish.[1]

Some authors question whether the "mere" introduction of more women into scientific fields will accomplish the liberation of science from its male mold. A few writers warn women not to attempt scientific careers, and several characterize those who belong to societies of women in science, technology, and medicine as being forever fixated at a rather primitive level of feminist consciousness.[3]

Virtually all the radical feminist writers on issues of gender and science herald their analysis as being a deep and dangerous challenge to the very foundations of modern science. But I would argue that what is valuable in the analysis is by no means uniquely a feminist contribution. Discussions of misuse of the banner of scientific objectivity, the tyranny of experts, the problem of pseudoscience, the need to take human and environmental factors into account, the advisability of encouraging women, minorities, and the economically disadvantaged to participate in the scientific enterprise-- all predate the new radical feminist analysis by many years. And unfortunately, the radical feminist analysis suffers from problems not shared by other socio-political critiques of modern science, and has some particularly disturbing implications for educators.

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Objections to the radical feminist analysis of gender and science can be made on many levels. Here, I shall confine myself to mentioning those I consider the most relevant for GASAT participants. First, the analysis is far too general, vague, and at the same time too categorical to be useful for educators. Many of the writers on this topic employ cartoon-character stereotypes of science, scientists, men, and women. They show little understanding of the diversity of scientific workstyles and personalities; little perception that science involves creativity, imagination, intuition, and a sense of fun. Science by its nature is welcoming of innovation, tolerant of diversity-- these are aspects which should be emphasized by those who wish to encourage girls' interest in the sciences.

Second, radical feminist writers, even the most careful of them, often make unsubstantiated and unwarranted extensions from the human sciences (such as sociobiology, psychology, primatology, physiology) to all of the natural sciences and mathematics. Many commentators have carefully and convincingly documented instances of systematic gender biases in the life sciences,[6] but they have yet to cite an example of gender bias in the content (as opposed to the style) of the physical sciences and mathematics. Regrettably, this does not stop them from generalizing their analysis.

Third, the radical feminist analysis is ahistorical and acultural. It fails to take into account cross-cultural comparisons and changing historical circumstances-- circumstances changing too rapidly for the "psychosocial construction of femininity," to use the jargon, to be a satisfactory mode of explanation: gender roles and expectations are neither so constant nor so consistent through time and place as the radical feminists seem to think.[7]

Finally, the radical feminist analysis could be seen as playing into the hands of those who promote the newest wave of cognitive pseudo-science (brain lateralization studies). Poorly constructed and misinterpreted studies of the supposedly vast cognitive differences between the sexes are exciting much attention in the media today. One of the most notorious and widely-publicized of these claims to prove that girls are inferior to boys in mathematical ability.[8] When the media are blaring out the news that "radical" feminists have come to the same conclusion about women's unsuitability for science (or science's unsuitability for women) as have the cognitive "specialists," the combination could be disastrous for girls who need encouragement to think of a scientific career.

As someone who firmly believes in the importance of encouraging young girls and women of all social backgrounds, races, and cultures to attain their full human potential in whatever area of endeavor they choose, I would like to insert a note of caution with regard to this trend of feminist analysis. I believe that there is a real danger in advocating essentialist (whether biological or psychosocial) ideas of "feminine" as opposed to "masculine" science, and in propagandizing the theory that science and technology as practiced today are innately anti-feminine in content. First, one risks reinforcing cultural stereotypes of the sciences as fields alien to girls. Second, one could alienate potential and actual supporters of opportunities for women among practicing scientists of both sexes. Third, one could cause misunderstandings and a certain amount of bitterness among minorities and other disadvantaged groups who do not have the luxury to subscribe to trendy, exclusionist theories. Finally, one risks labeling (and therefore straightjacketing) girls and young women as perniciously as have opponents of equal opportunity in the past.

Our goal should be tolerance, diversity, encouragement of a multiplicity of lifestyles and personalities. A theory which emphasizes polarity and fixity is too restricting, even when it is presented to us as an analysis of liberation. We have to fight against stereotypes, to promote the notion that all work is human work-- as acceptable for women as it is for men. Concretely, we need to attack the general myth of women's invisibility in scientific fields. There are countless success stories of women in science and technology-- they should be widely publicized in the schools.

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NOTES

1. See, for example, Evelyn Fox Keller, *Reflections on Gender and Science* (New Haven: Yale University Press, 1985); Ruth Hubbard, Mary Sue Henifin and Barbara Fried, eds., *Women Look at Biology Looking at Women* (Cambridge, MA: Schenkman Publishing Company, 1979); Carolyn Merchant, *The Death of Nature* (San Francisco: Harper & Row, 1980); Elizabeth Fee, "A Feminist Critique of Scientific Objectivity," *Science for the People*, *14*, No. 4 (July/August 1982); Ruth Bleier, *Science and Gender: A Critique of Biology and Its Theories on Women* (New York: Pergamon Press, 1984); Leanna Standish, "Women, Work, & the Scientific Enterprise," *Science for the People*, *14*, No. 5 (September/October 1982); Bonnie B. Spanier, "Women's Studies and the Natural Sciences: A Decade of Change," *Frontiers*, *VIII*, No. 3 (1986); Ruth Wallsgrove, "The Masculine Face of Science," *Alice Through the Microscope*, Lynda Birke, et al. eds., (London: Virago Ltd., 1980); Barbara Dodds Stanford, "Women and Science," *Science for the People*, *18*, No. 1 (January/February 1986); Sandra Harding, *The Science Question in Feminism* (Ithaca, NY: Cornell University Press, 1986).

2. See Nancy Chodorow, *The Reproduction of Mothering: Psychoanalysis and the Sociobiology of Gender* (Berkeley: University of California Press, 1978); and Dorothy Dinnerstein, *The Mermaid and the Minotaur* (New York: Harper/Colophon Books, 1976); and compare with Adrienne Rich's explanation of growing up, according to which girls must disidentify with mother to focus on men, whereas boys do not need to do so. (Rich, *Of Woman Born* (New York: Norton, 1976), pp. 218-219; cited in Bleier, pp. 175-176.)

3. Standish, "Women, Work, & the Scientific Enterprise," p. 14.

4. Hilda Hein also makes much of woman's "relationality" in her "Women and Science: Fitting Men to Think About Nature," *International Journal of Women's Studies*, 4, No. 4 (1981).

5. See the Stanford and Standish articles in Science for the People; note also the implicit condescension toward women scientists in Spanier, "Women's Studies and the Natural Sciences," especially p. 70. For a critique of these positions, see Mary Beth Ruskai, "Letter on Feminism and Women in Science," Association for Women in Mathematics Newsletter, 16, No. 3 (May/June 1986), and her presentation to Boston AWIS on February 19, 1987.

6. See Bleier's excellent case studies in Science and Gender; Marion Lowe, "Sociobiology and Sex Differences," Signs, 4, No. 1 (1978); Donna Haraway, "Animal Sociology and a Natural Economy of the Body Politic, Parts I and II" Signs, 4, No. (1978); Sarah Blaffer Hrdy, The Woman That Never Evolved (Cambridge: Havard University Press, 1981).

7. For sophisticated critiques of gender polarity thinking in feminism, see Natalie Zemon Davis, "'Women's History' in Transition: The European Case," Feminist Studies, 3, No. 3/4 (Spring/Summer 1976); Ruth H. Bloch, "Untangling the Roots of Modern Sex Roles: A Survey of Four Centuries of Change," Signs, 4, No. (1978); Joan W. Scott, "Gender: A Useful Category of Historical Analysis," The American Historical Review, 91, No. 5 (1986).

8. For a review of the literature on cognitive sex differences, see Jeannette McGlone et al., "Sex Differences in Human Brain Asymmetry: A Critical Survey," The Behavioral and Brain Sciences, 3 (1980); S. L. Star, "Sex Differences and the Dichotomization of the Brain," in Ruth Hubbard and Marion Lowe, eds., Genes and Gender II (New York: Gordian Press, 1979); Joe Alper, "Brain Asymmetries: Sex Roles or Sex Differences?" Science for the People, 17, No. 5 (1985). For a concise and elegant critique of brain lateralization work, see Bleier, Science and Gender, pp. 92-93; for a longer discussion, see Joseph S. Alper, "Sex Differences in Brain Asymmetry: A Critical Analysis," Feminist Studies, 11, No. 1 (Spring 1985).

For the work on gender differences in mathematical ability, see Camilla

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Benbow and Julian Stanley, "Sex differences in mathematical ability: fact or artifact?", Science, 210 (1980). For refutations of the Benbow and Stanley work, see the mathematicians Alice Schafer's and Mary Gray's editorial "Sex and mathematics," Science, 211 (1981); and numerous articles in the Association for Women in Mathematics Newsletter.

A SUMMER RESEARCH PROGRAM FOR GRADE 11 HIGH SCHOOL GIRLS

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Summary

One of the on-going programs of WISEST, a committee of the Vice-President (Research) at the University of Alberta on Women in Scholarship, Engineering, Science and Technology, has involved having high school girls in Grade 11 (their second last year of school) spend six weeks during the summer months in research groups in the Faculties of Science and Engineering at the University of Alberta. The purpose of the program is to develop the interest of girls in careers in the sciences and engineering and to provide them with information which will make it more likely that they will succeed in their chosen field. The program has been held for three summers and has been successful in meeting these goals. Several students who participated during the summer of 1984 are now in non-traditional areas of the study at University. Further, with the attention it has received from the media, the program has helped raise the awareness of the general public, and especially of the University staff who have acted as supervisors, to the need for more women in the fields of science, engineering and technology.

Introduction

During their final year in high school, girls make many career decisions which have a profound effect on the direction of their lives.[1] One of the many influences on choices made at this stage is knowledge of what a specific career entails. Often, girls have little idea of what is involved in technological jobs. For example, they do not know what civil engineers do on a day to day basis, and are therefore unlikely to opt for career in this field. How can some of the missing information with respect to scientific and technological careers be provided? At the University of Alberta a committee on Women in Scholarship, Engineering, Science and Technology (WISEST)[2] has a mandate to take action to try to increase the participation of women in science, engineering and technology. One of the on-going programs of WISEST attempts to encourage girls to look ahead to their careers and gives them hands-on experience of a variety of science and engineering disciplines. In the program, high school girls having completed grade 11, their penultimate year in school, spend six weeks during July and August at the University of Alberta as members of a research group in the sciences and engineering. The program has been in operation for three summers. Six girls were placed in 1984, fourteen in 1985 and twenty-two in 1986. They worked in the departments of civil, electrical, mechanical and mineral engineering, and in the science departments of botany, chemistry, computing science, genetics, mathematics, microbiology, physics and zoology. In addition to their experience in the research groups, the girls met together as a group each week for WISEST organized activities.[3] A brief description and evaluation of the program to date follows.

Recruitment of Supervisor and Students

Academic staff at the University of Alberta were recruited as supervisors of the students. The faculty members, female or male, who agreed to take students were supportive of the career aspirations of young women and recognized that a considerable outlay of time and effort would be required to train and supervise the students. It was emphasized that the students were to be given the opportunity to do more than wash dishes, and if at all possible, were to be directly involved with some aspect of the research in progress. The staff who took students during the first summer were contacted to discover whether they were willing to continue as supervisors; publicity about the program and subsequent contact of individual faculty members has resulted in a pool of University researchers willing to supervise the students.

Recruitment of students has been restricted to schools within the city of Edmonton and its immediate surrounding communities. Thus, all students chosen for the program can commute easily to the University. Application forms were prepared with the co-operation of the science supervisors of the Edmonton Public and Catholic School Boards and distributed to science teachers in high schools within the area. Along with the application forms is sent a list of research projects with a brief description of each and the background in course work which would be most suitable to each project. The student indicates project preference on the form. Teachers are asked to encourage those young women to apply who, for whatever reason, might not otherwise consider a career in science or engineering.

Each student is paid an honorarium of $750.00 for the six weeks involvement with the program. Funding for the program has come from Federal and Provincial Government grants, from a local philanthropic foundation and from the University. The number of places available has been dictated by funding rather than by availability of supervisors or students. For the twenty-six places available in the Summer 1986 program, over one hundred applications were received. Choosing the students has been described by a member of the selection committee as both an exhilarating and a depressing experience; exhilarating because of the genuine interest and quality of the students, and depressing because so many excellent students could not be accepted for the program. Students are chosen using several criteria; in fairness to their University supervisors, they must show strong academic achievement in the sciences; they should have qualifications appropriate to the project to which they are being assigned; they should express a strong interest in the experiences which the program will offer; they should be at least somewhat open-minded about their career plans. All other criteria being equal, students who indicate that they are unsure of their career direction will be given an opportunity to be part of the program over students who firmly state that they are committed to a career in a certain field.

Activities During the Program

A program co-ordinator was hired for the summers of 1985 and 1986. She visited the students regularly in their laboratories and maintained close contact with their supervisors. In this way problems could be identified and solutions discussed; difficulties which arose in the first year of the program were avoided in the subsequent years, and this contact is seen as very important from everyone's point of view. The program co-ordinator arranged weekly meetings and in the summer of 1986 designated a location where she was available to chat with the students over lunch. This proved to be appreciated by those students who were the lone representatives of the program in their department, and who were often the only female in the research group.

During the weekly meetings, students had an opportunity to get to know one another. Activities included tours of University facilities such as the libraries. At one meeting, the students explored their own sex stereotyping. They rated a list of behaviours and occupations for their suitability to females or males. This exercise was useful in making the young women more aware of their own perceptions. The girls frequently described what they would like to be doing in ten years as 'working at a secure job which is interesting', rather than a specific career such as a bank manager, a doctor or a pharmacist. This exercise stimulates the girls into thinking more precisely about their futures and leads to a discussion about planning to achieve specific goals. This has been shown to be important in the careers of top leaders, whether the specific goal is the one finally reached or not.[4] Inevitably, the discussion results in a sharing by several of the girls of their desire to have a stable family and a satisfying career and of the demands of time and energy which would have to be met to satisfy their goals.

At another meeting, the young women met in small groups with women engineers and scientists and talked informally with them about their every-day lives. At yet other meetings, an employment counsellor talked of trends in the job market and of the qualifications needed for a variety of technological posts, and each student described the work they were doing in their project. The latter allowed the students to learn something about each field in which a WISEST program participant was located. At the end of the six weeks, students submitted to the program co-ordinator a report of their research.

Assessment of the Program

The majority of supervisors were very positive when evaluating the program. Of the twenty-two faculty members in the 1986 program, seventeen gave it the most positive rating on a scale of one to five. All faculty members who have already supervised students have indicated a willingness to take students in future summers, this in spite of the fact that they had to spend much time with their students. This is a strong indication that the supervisors found the students' contributions to be valuable. Having recognized the level at which a grade 11 student would be able to perform in the laboratory, 75% of the supervisors felt that their students were more interested and more capable than they had expected. The others felt that the students performed as well as they had expected. Several supervisors commented on the enthusiasm and willingness to learn of their students. Of the eighteen science and engineering faculty members who supervised young women in the summer of 1986, only two were female. The positive reaction of the male supervisors to the performance of their female students and their encouragement of them, has been noted with pleasure by WISEST.

All of the student evaluations have been positive. They indicated that they enjoyed the program and had benefitted from it. Particularly mentioned was the value of the hands-on experience of science and engineering. Many of the girls said that they had been encouraged to continue their school studies in mathematics and science. They also appreciated learning not only about the field in which they were working, but also about all of the areas in which students had been placed as they shared their work with one another. The group activity which the students felt to be most valuable was the opportunity to meet informally with women working in non-traditional fields; the girls commented that they have little opportunity to meet and question people, far less women, from science and engineering professions. One of the major reactions of the students which, for the most part, had not been foreseen by the organizers was the delight they felt at becoming familiar with a university campus, finding it less intimidating than they had expected and becoming convinced that they would be able to cope with a university education system.

Has the program affected the career choices of the students? Among the first group of six girls who were in the 1984 program, all are now attending a post-secondary institution, and three of them are studying in the fields in which they worked during the summer. One of the girls was the top student in grade 12 in the Edmonton Public School system. This girl is studying engineering at University, a career which she had not considered before her exposure to the field in her summer job. Follow-up of the 1985 summer students is incomplete, but results to date indicate that many of the girls are considering careers in fields to which they were exposed during the summer.

It would have been surprising, and disappointing, if the experience of the WISEST program had not broadened the career plans of the students. In addition, an effect which it has had on the majority of the girls is to increase their self-confidence. A similar result was noted in a program at York University^5.

Students from grade 11 were chosen for this program for two reasons. Firstly, they still have a year to spend in high school when they will make final course choices and think about their future plans, and secondly it was expected they would share their experiences with their school friends during grade 12. Since it is recognized that the WISEST program at the University of Alberta can accommodate and therefore directly influence a very small fraction of female high school students, this sharing is seen as a way of increasing the effect of the program.

Not only has the program affected the girls and boys who were direct participants in it and their school peers, but through publicity at the University and attention from the local press, radio and television, it has helped to stimulate discussion about the merits of having more women pursue careers in the sciences and engineering.

The administration at the University of Alberta has been strongly supportive of the program, and the participants in 1985 and 1986 were welcomed to the University by its President, Dr. Myer Horowitz. Both financial and moral support has been provided by the Vice-President Research, Dr. J. Gordin Kaplan who has also taken a strong leadership role as the chairperson of WISEST. The government of the Province of Alberta has listed the science education of girls as one of its priorities, and in addition to supporting the program financially, the guest of honour and speaker at the closing lunch for the 1986 participants was the Honourable Nancy Betkowski, Minister of Education. Such support gives the program credibility and is very important to both students and organizers. Perhaps, most rewarding for the supervisors and co-ordinators of the program has been the surprise and delight expressed by the students when they realize that 'This is science; it is important; I can do it!'

Acknowledgements

The author acknowledges the time and effort given to this activity by members of WISEST and particularly Dr. Dallas Cullen, Faculty of Business, University of Alberta who organized the first program in the summer of 1984 and Elizabeth McClintock, Dr. Girija Rajaram and Linda Hall who co-ordinated the 1985 and 1986 programs. The co-operation and support of Bernie Galbraith, Science Supervisor, Edmonton Public School Board, and Mervyn Lynch, Science Supervisor, Edmonton Catholic School Board, are gratefully acknowledged.

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Technology Projects
for girls in public schools and high schools
in Denmark

Hjørdis Meier
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Marianne Abrahamsen
Marselisborg Gymnasium

Computer - Studies Courses from a girl's/woman's point of view

As the prediction for the industrial development in Denmark shows that in the next decade there will be a shortage of man-power in the technical profession, the Danish Employers' association is now running a campaign aimed at encouraging girls to choose these so called employment guaranteeing educations, ie partly the traditional male subjects, and partly the new technological educations. It is obvious that the technical development and pressure put on the traditional female educations, makes it important that women choose the less traditional, but this necessity also uncovers the need for new improved teaching in order to make it at all possible for girls to feel able to aquire technical knowledge, and not least to give them the will to want to deal with the technical subject areas.

In the following we will give an account both of personal experiences with teaching in New Technology, and of experimental projects within schools and gymnasiums (colleges for 16-19 year olds)

Further education courses in computer-studies for women teachers

In the academic year 1984/85 I took part in a years course in 'Informatik', started by Denmark's Lærehøjskole (education college for teachers only) in Århus. There had been many applications for this course, mostly from male teachers, and therefore an application for more places was made to the Ministry og Education and luckily

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it was possible to arrange 5 more courses with the same contents.

When at the [illegible] it became clear that it might be necessary to give special favourable conditions, so that the few female applicants wouldn't drown completely in the male dominated technical terminology and worldly experience, a special female only group was set up.

Unfortunately the women involved were not informed of these circumstances nor of the considerations which lay behind this. Therefore when the course started there was a distinctly bad atmosphere, the women felt quite rightly that they had been forced into an experiment and were hostages for some gender-political interests which they couldn't see were in any of their own interests. Their main objective was to learn something about computer technology, and one felt somewhat repudiated when a female technological group wasn't seen to be seriously recognised.

With this background the development throughout the academic year was remarkable, not only did nearly all say that due to the friendly atmosphere experienced in the group, and because in the teaching situation they couldn't avoid the responsibility of technological progress, they had learnt much more on the purely technical side than it would supposedly have been possible in a group dominated by men.

But besides that, we learnt how much society and those expectations we have of ourselves gender-wise meant in the teaching and how important it also is to put technological understanding in a wider frame of comprehension, in order to get those girls and women who know nothing of technology involved.

Several of the course members worked further with their new knowledge in their own schools after the course, and which among other things has resulted in experimental projects with teachers of data, concentrating on the female point of view, and more programme development projects for example to do with physics and mathematics.

Computer-Studies instructor courses and the importance of the female network

For me personally it has resulted in enrolling myself as computer-studies instructor on some intrductory courses, which were to be held in all the municipal schools.

I was the only woman on the instructors course, and was among 17 men all clever and very interested in technology.

The importance of network shows in this connection. I have, after starting work as an instructor, met many women who have said that they too have wished towork on the same level as me, but have held back due to two reasons:

- First of all they didn't feel sufficiently qualified.
- Secondly they're afraid that their teaching in school will suffer, "It's a shame if the children have to be without their class teacher for shorter or longer periods of time."

In order to overcome this type of barrier, in this present historical phase, it is infinitely important to be able to get the necessary strenght and inspiration in a well functioning network, for example as the one established in Vejle. (See article by Bente Stig, Gasat 1985 & 1987.)

I have since then been on several different computer-studies courses, all typically dominated by men, and I experience that for me, with my female/humanistic background, I have to use many roundabout methods

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every time I have to conquer a piece of technological knowledge.

Experiences from teaching girls and women technology

I too am now teaching in Information Technology, partly a female group at Denmark's Lærerhøjskole, and partly mixed classes in areas of local government, and I find it relatively easy, for me with my background, to teach what I know to other women.

As a result both of the powerful" interest and female political considerations, there has in recent years been several experimental projects to do with technology teaching from the female point of view, and we can now begin to draw conclusions from the results of these experiments.

Experiments with girls and technology at gymnasium

A little about the gymnasium today

1) Since the gymnasium is a direct continuation of school (1/3 of pupils continue here) the same problems tend to be found, both to do with pupils' and teachers' attitudes, and education together with subject matter.

The Pupils

The Danish gymnasium takes 3 years which are structured round two main directions: one linguistic and one mathematical. In the second and third years for the linguists there's the choice of 4 branches: modern linguistics, social linguistics, music linguistics, and classical linguistics.
For the mathematicians there's the choice of: mathematics-physics, natural sciences, social sciences, social mathematics and music.

The distribution of girls and boys going to gymnasium is 60% girls and 40% boys.

Many girls have the attitude that they're best at languages and that the natural sciences and tehnological subjects are male subjects. Within the last 10 years though, there has been a gradual change in girls' choice of direction. The mathematical side used to have 90% boys and 10% girls and the opposite on the linguistic side, whereas the figures now are:

	Girls	Boys
Linguistics	80%	20%
Mathematics	40%	60%

The Teachers

Among the teachers is the division between men and women more or less equal, while the division of subjects is the traditional with mostly men teaching the natural sciences and mostly women teaching languages and humanity subjects.

The majority of the teachers have been qualified before the new technology became part of an education, and they have therefore had to suppliment their knowledge in this area with further education in their spare time.

Subject Contents

The subject contents of the natural sciences with regard to topics, practicals and exemplary material are either aimed at the boys' world or so abstract that the girls quickly lose interest because in their choice of what they want to study and spend time on, go after subjects which have an obvious and immediate use.

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75% opt out of the mathematical-physics branch and divide themselves in the natural sciences (50%) and social sciences and music (altogether 25%) ie the majority of girls choose the branches which aim towards the traditional female educations, away from the technical areas.

Role divisions in the technical/natural science subjects

Girls' attitude to these subjects is described in more detail in Karin Beyer's article, and here it need only be mentioned that the typical pattern in the practical subjects is that the boys concern themselves with the practical side while the girls quickly assume the role as secretary ie the one who takes notes.

2) New Initiations

In the light of this situation the Ministry of Education has taken various initiatives. There has been pressure from within by female teachers and researchers, who have,through investigations of gymnasiums, pointed out the inexpediency for girls in this situation, in that it limits their possibilities within their education. Pressure has also been felt from the labour market, which as has been mentioned earlier, needs workers in the technical fields.

Introducing Computer-Studies in teaching

In order that everyone, regardless of sex and subject, gain knowledge and practice using this new technology and understands its importance both in a wider context and its influence on the individual, 30 hours of computer-studies was madecompulsory in 1984 for all first year gymnasium pupils. The courses involes handling texts, programming and understanding its perspectives. The pupils are taught by one of their own teachers (both in linguistics/humanities and the natural sciences) as all the [illegible] teachers in the country have taken a

40 hours course in computer-studies.

This arrangement has been made to ensure that technology is not for the experts only, but is available to everyone, and covers all subjects and both sexes.

Difficulties have been found particularly in trying to get teaching materials/programmes, especially in languages and humanities, which again has increased the distortion of gender divided interests.

But the wide mobilizing has proved positive to both teachers and pupils who have all had their technical anxiety reduced. The courses have follow-ups in the second and third years of gymnasium.

Structure changes and subject content

The relatively strict gymnasium structure outlined generally in the introduction, where pupils can only choose complete subject packets, linguistic or scientific, and which enforces gender specific choices, will hopefully change as a new structure is to be introduced from 1 August 1988.

The pupils still have to choose between linguistics or mathematics, but thereafter have the opportunity to choose more freely, so that one half of their lessons consist of the compulsory subjects, while the other half are of their own choice but with certain requirements.

The ideal, from a gender-political consideration would be a joint first year, where everyone had both languages and natural science/technical subjects, so that some of the gender prejudices could be weeded out. But it is more positive that the new structure makes it possible to choose both languages and natural sciences at a high level. For example it will be possible to choose english, biology, mathematics, technology without having to have physics, which experience shows to be a subject girls steer clear of, and which thereby for example prevents girls taking maths at a high level, and it could help give girls more opportunities both with regard to their education and occupation.

New subjects/new subject content

Economics and technology are to be introduced as new subjects, with contents aimed more specifically at girls' interests.

Physics and mathematics change, in that the compulsory material is reduced and replaced with topics which can be chosen with regard to the pupils' wishes and interests.

An Experiment with TECHNOLOGY at Marselisborg Gymnasium

Several gymnasiums have carried out experiments introducing new technology; a collaboration of the professional world and the gymnasium, but only in previously mentioned experiments has the starting point been specifically concentrating on girls' experiences.

''Teaching in technological subjects and physics/chemistry will be organised with a basis beneficial to girls, so that through choice of exemplary material, practicals, teaching methods etc, every effort is made to achieve equality between girls and boys...''

and

''...futhermore the experiments will strive to develop the pupils' ability to think and express themselves creatively dependent on their various backgrounds. Their creative subject: film, art and music, as well as drama and sports can enter into the production phase for example in connection with projects dealing with the interaction of technology and other subjects."

A short account of the experiment

THE AIM is to give the pupils:

1. the general education the gymnasium normally gives preparing for further education.

2. insight into the new technology, here through computer-studies courses.

3. insight into technology's influence on, and correlation with the individual and society.

TEACHING has its own starting points in each individual subjects, the number of periods in each is given at the back of this booklet. But new in connection with the gymnasium structure is the carrying out of a subject integration project, for a longer period of time in each of the three gymnasium years.

1g: PRODUCTION TECHNOLOGY
(eg production planning, industrial robots)

2g: BIOTECHNOLOGY
(eg industrial medicine, genetics)

3g: INFORMATION TECHNOLOGY
(eg the new mass media)

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An important part of the teaching involves

WORK EXPERIENCE TRAINING

in the various business, trades and public institutions.

Also topics like technological history, economic politics, mathematical models, natural sciences, body language, communication and technology, nature - technology will be dealt with in several subjects, to among other things, comprehensively illustrate and discuss technology's development and consequences.

Differentiated is also that:

Mathematics, physics/chemistry and English are all taught to a high level, and at the same time teaching in Danish and social studies is to be maintained in comparison with the mathematics-physics branch.

English or two other foreign languages.

The range of subjects includes music, art, [illegible] and drama.

All [illegible] [illegible] and other arts [illegible] [illegible] [illegible] [illegible].

The experiment is not yet concluded, the first group started in 1986 and the school has been granted permission for 3 trial periods, each lasting 3 years. But already the advantages for the girls, integrating [illegible] [illegible] [illegible] [illegible] [illegible] can be seen, in that [illegible] [illegible] and [illegible] to work with technology, theoretically as well as practically. [illegible] [illegible] than [illegible] [illegible] mathematical [illegible].

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Examples:

- To make sure that boys and girls were equally represented in the class, interviewees were, before their acceptance, informed that in the case of there being too many applicants, the school would choose the girls in preference to the boys. This had a positive effect, where other similar projects only managed to mobilise 2-3 girls, compared with the two existing classes which have 12 girls &14 boys and 9 girls & 17 boys.

This has meant that equal weight could be put on both girl and boy interests.

- Physics has for example chosen the sewing machine as a topic rather than the steam engine. Practical groups have been formed so that there are some with only girls, which has been beneficial as girls are given access to the experimental side.

- Practical groups in the private industry sector put the theoretical teaching into relevant frames, which fulfils the girls' wishes to see how the theory is used.

- The firms/businesses chosen are for example in the textile industry. Even though it is not the actual product, but the new technology put into use in the production and administration processes, is it interesting that it is relative to the girl's world.

- Drama is included as an integral part of teaching. Eg one class has performed 'The Luddites' by Ernst Toller, which is a working integration of english, danish, music, sport and drama.

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Conclusion

Results from all these different experiments show more or less identically that the following criteria have to be met if girls/women are to profit from an education in and with technology.

- Firstly they must be allowed to work in socially well functioning girl-groups, as co-operation between girls is much important in achieving a good result, than it is for boys, who are much more competitive, working besides each other rather than together. Further more, these gender divided groups seperates the girls from the boys' technical advantage.

- Secondly it must be possible to relate the topics used, to the girls' world and also in a wider social context and understanding. This also helps the girls to overcome this idea they have, that they can't understand technology, in contrast to the boys who confidently approach the machines certain that they can handle them.

- Thirdly work experience is profitable in that it puts the abstract/theoretical teaching in concrete frames, whereby girls get the chance to experience how the theories are used. It is also just as important that the production trades are of interest to the girls eg the textile branch.

- Fourthly girls achieve the best result if they're taught and advised by a technology interested woman teacher.

-Fifthly it's very important for the girls' self-esteem that they don't feel that less is expected of them, than of the boys.

The last and most important conclusion is that girls' and boys' attitudes to technological topics are different, and it is important that at all teaching levels,teachers are aware of these differnces in such a way that the teaching will benefit both sexes, so that girls are not forced to work only on boys' conditions.

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A MULTI-FACETED APPROACH TO THE RECRUITMENT OF WOMEN INTO ENGINEERING

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BACKGROUND

In the early 1970s engineering enrollments in colleges and universities across the United States were declining and engineering administrators were investigating alternatives to reverse that trend. During this same time period the roles and attitudes of women in the United States were undergoing dramatic change: women were more apt to consider non-traditional career paths and opportunities in the traditionally female occupations, like teaching, were declining. It was also a fact that women composed less than 1 percent of the engineering work force, and industry was becoming aware of the legal and economic advantages of tapping this source of potential engineers. These factors combined to create an environment extremely receptive to women interested in entering the field of engineering.

The Women in Engineering Programs at Purdue have taken a multi-faceted approach to increase the participation of women in the field of engineering. In the beginning programs were developed with government funding through the Women's Educational Equity Act and funds solicited from industrial foundations. Since then, the Purdue University Schools of Engineering have institutionalized several of the programs, some have become self supporting and some continue with grants from industry. In the description of programs which follows, source of funding will be indicated whenever possible.

Of the original programs developed in 1972, several still exist. Since then new programs have been added as special needs have become evident. Figure 1 shows the duration and target group of major recruitment activities of the Women in Engineering Program.

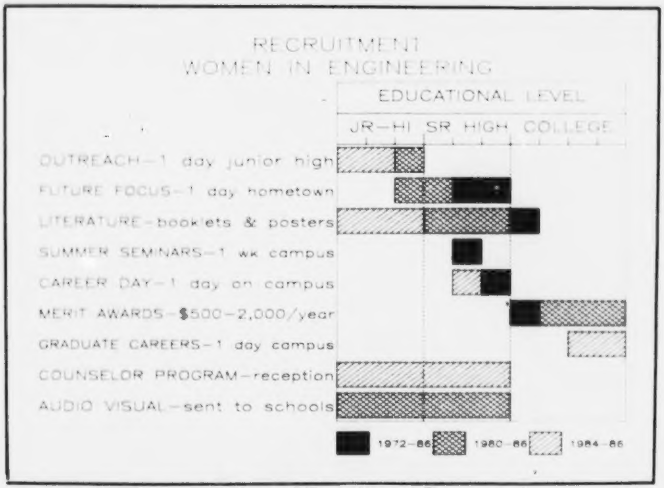

Figure 1 Duration and Focus of Recruitment Programs

Although there is a diverse combination of activities comprising the Women in Engineering Programs at Purdue, several underlying principles have guided their development.

Focus on career. Purdue University has long been recognized as one of the most outstanding engineering schools in the United States. Therefore, recruitment efforts focus on increasing the "pool" of young women who consider engineering as an appropriate career choice. It is assumed that a reasonable proportion of these young women will choose Purdue as the place to pursue their engineering education.

Role Models. In evaluating the many components of the Women in Engineering Programs, the importance of role models has always been evident. Students consistently indicate the value and benefit of talking with women engineers and engineering students. Therefore, role models are incorporated into programs wherever possible.

Minority focus. While the minority population (Blacks, Hispanics and American Indians) in the state of Indiana is very small, care is taken in all Women in Engineering Programs to include special concerns of minority women and to work cooperatively with the Minority Engineering Programs at Purdue whenever possible.

Developing a support network. One of the most important issues facing young women who are considering a non-traditional career is the reaction of their family and friends. In response to this concern several programs intentionally include parents, techers, and counselors. Perhaps even more importantly, programs encourage interaction among participants so that they develop the feeling that many other young women share their interests and career plans.

Continuity of contact. The Women in Engineering Programs have always tried to provide continued contact with students from Junior High School through their enrollment at Purdue. This continuity of effort assures young women that individuals at Purdue are concerned about their educational development not just in soliciting their enrollment and then ignoring them.

A variety of approaches. Over the years programs have been developed which offer a variety of approaches--some through mailings, some through telephone contacts, some off campus and some on campus. As students differ in their personality they may respond better to one type of contact than another.

PROGRAM ACTIVITIES

Grade School/Junior High Poster - A poster was designed to reach girls between the age of 6 and 12 years old. It consists of a colorful drawing of 5 young women - one dressed in a suit with a briefcase, one in jeans with a small child holding on to her leg, one dressed as a student carrying books, one in a tennis outfit and one in a work clothes and hard hat with construction plans under her arm. The poster asks, "Can you guess which of these women are engineers?" Printed matter on the poster describes activities which are common to many who pursue engineering. It also lists familiar products which engineers have designed and possible areas of work for engineers in the future. The poster was distributed to libraries and counselors in grade schools and junior high schools throughout the state of Indiana. Each poster had tear-off postcards which individuals could return to the Women in Engineering Programs, requesting their own copy of the poster or additional information. In the first 3 months after the posters were distributed, more than 250 requests were received from girls in Indiana. The poster was developed and distributed with industrial grants.

Career Information Movie/Video Tape - Work is nearing completion on a movie about women in engineering. Alumnae from Purdue University were used as the main subjects of the film, depicting how women combine family life, recreational activities and individual interests with a career as demanding as engineering. When complete the movie will be made available to teachers and counselors throughout the midwest as well as to Society of Women Engineers groups and Women in Engineering Programs at other universities throughout the United States. It will be presented in 16mm film and VHS format video tape. Groups and schools may borrow copies from Purdue University or buy video tapes at a nominal reproduction cost (approximately $10). The production of this film was sponsored by part of a $20,000 Affirmative Action Award granted by the president of Purdue University.

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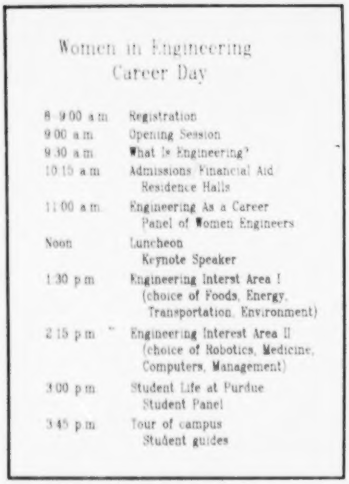
Women in Engineering Career Day - This one day program is offered for high school juniors in the spring and seniors in the fall. It brings more than 400 high school young women and 200 parents to the Purdue campus to see the engineering facilities, meet students and faculty and talk with working women engineers. Parents are invited to remain with their daughters during the morning sessions and luncheon, but have a separate program in the afternoon so that their daughters might be more relaxed in interacting with Purdue students. Figure 2 shows a sample program for Career Day. Each Career Day is supported in part by industrial grants, but students and parents pay a registration fee to help defray costs. Approximately 50% of the senior women who attend Career Day enroll at Purdue in engineering for the following fall semester.



Women in Engineering
Career Day

8-9:00 a.m.	Registration
9:00 a.m.	Opening Session
9:30 a.m.	What Is Engineering?
10:15 a.m.	Admissions Financial Aid Residence Halls
11:00 a.m.	Engineering As a Career Panel of Women Engineers
Noon	Luncheon Keynote Speaker
1:30 p.m.	Engineering Interst Area I (choice of Foods, Energy, Transportation, Environment)
2:15 p.m.	Engineering Interest Area II (choice of Robotics, Medicine, Computers, Management)
3:00 p.m.	Student Life at Purdue Student Panel
3:45 p.m.	Tour of campus Student guides

Figure 2 Women in Engineering
Career Day Schedule

Slide-Tape Program - A program of slides synchronized with an audio tape was developed to inform young women in high school about engineering as a career and Purdue as an engineering institution. This program is distributed, when requested, to high school teachers or counselors for a week of use as they see appropriate. Initial publicity for this program went out in 1981. In that year 2744 young women viewed the program. 92% of the teachers using the slide/tape presentation gave it a rating of "excellent" or "good" and 98% said they would use the program again. It is also used as part of other women in engineering programs such as Career Day and Future Focus.

Counselor Reception - In an effort to maintain a close working relationship with career counselors throughout the state of Indiana, the Women in Engineering Programs has sponsored an exhibit and reception at the annual state conference of counselors. Counselors are invited to talk with the director of the Women in Engineering Programs and a number of engineering students and alumnae. Career information materials are on display and forms are available for counselors to request larger quantities of the printed materials. This reception is sponsored by the Purdue Student Section of the Society of Women Engineers. If successful this program may be expanded to a conference of high school mathematics teachers.

Women in Engineering Poster - A full color poster encouraging high school seniors to join the women engineering students at Purdue is mailed to more than 2,000 outstanding high school seniors each year. The poster shows 200 women students spelling out the words "Women in Engineering" on the field of the Purdue football stadium. In large, bold writing the poster says "We're looking for a few (more) good women in Engineering. (A parody of the U.S. Marine ads "We're looking for a few good men") The back of the poster includes brief interviews with women engineering students at Purdue and information about engineering education and careers. The poster was developed with funds from industrial grants.

Future Focus - These programs provide an opportunity for young women in high school to become acquainted with engineering as a career. Programs are held in major metropolitan areas in Indiana and surrounding communities. Typically a program is held in the evening at one of Purdue's regional campuses or a local hotel and is sponsored by a company located in the community. The program consists of a slide-tape presentation or movie about engineering, information about the engineering curriculum at Purdue, a panel of women engineering students and a panel of working women engineers. Parents, teachers and counselors are also invited to attend the program.

Seminar for Top Engineering Prospects - Students with superior academic backgrounds are invited to attend this week long seminar on the Purdue campus between their junior and senior year of high school. The program is coeducational, but women high school students are invited in sufficient numbers to ensure a fairly even distribution of males and females who attend the seminar The seminar includes instruction in computer programming, hands-on activities in engineering labs, engineering projects such as designing and building balsa wood gliders and bridges, and various social events. Students live in the university residence halls and are encouraged to make use of other university facilities during their free time. The program is self-supporting in that students are charged a fee to attend ($250 in 1987). Scholarships are available to qualified but financially needy students. Approximately one-third of these top students attending the seminar enroll at Purdue University after completing their senior year in high school.

Feminengineer - This newsletter includes articles written by women students in engineering. Articles focus on new areas of research at Purdue, women faculty members, achievements of women engineering alumnae and various campus activities. In addition to the prospective students who receive the newsletter, copies are sent to current students, alumnae, and industrial supporters.

Merit Awards - These awards, ranging from a one time award of $500 to a continuing award of $2,000 a year are sponsored by industry and offered to incoming freshman women students. Selection is based on high school academic record and standardized test scores as well as evidence of leadership and involvement in student or community organizations. Sponsoring companies are often interested in extending summer employment to these students.

Graduate Education Seminar - In response to the national concern regarding the number of women who continue their engineering studies at the graduate level, the Women in Engineering Programs expanded their efforts to include graduate school recruitment in 1986. A two day seminar was developed in cooperation with the Minority Engineering Program at Purdue University in which qualified minority and women students from throughout the United States participated. The seminar included speakers from graduate school administration, engineering faculty members, the director of the Graduate Education for Minorities Program and the project director from the Office of Opportunities in Science, American Association for the Advancement of Science. Students were also exposed to the various academic areas at Purdue University.

Graduate Education Brochure - In conjunction with the Graduate Education Seminar mentioned above, a brochure was developed to encourage women engineering students to pursue graduate education in engineering. Interviews with alumnae and faculty members concentrated on the value of graduate education and information regarding application, financing, timing, etc. was also included. Listings of national sources of funding for graduate education were also organized and included with the brochure. Both the seminar for graduate education and the brochure were funded by a $10,000 grant from the president of Purdue University as part of an Affirmative Action Award.

FUTURE EFFORTS

The question of where to focus attention for future activities is an important one. Enrollments of women engineering students, both nationally and at Purdue have plateaued in the last four years and a slight decline has been seen in Freshman enrollments the last two years (Figure 3). Accompanying this lack of growth has been diminished attention on the part of industry and government. Funds are less available and more programs are competing for existing funds. The areas listed below offer the most fertile avenues for continued support and renewed growth.

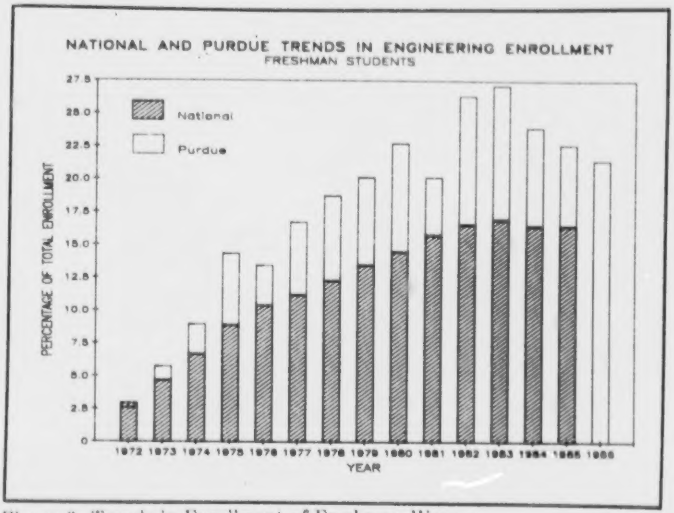


Figure 3 Trends in Enrollment of Freshman Women

Minority Women - Population statistics regarding the pool of prospective college students indicates a real need for the Women in Engineering Programs to focus on minority women. Not only is the percentage of minority students in the high school age pool increasing rapidly, but the population of minority students attracted to engineering has traditionally included a larger percentage of women than the corresponding population of Caucasian students.

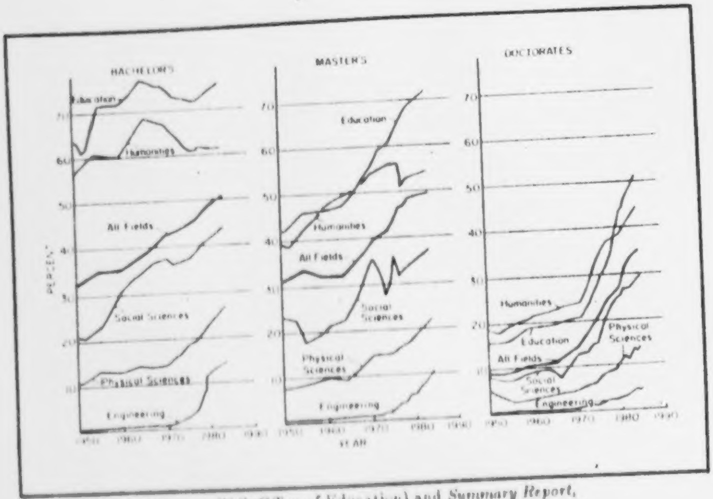
Graduate Programs - Engineering schools throughout the United States are concerned with the small percentages of women, minorities, and U.S. citizens choosing to continue their engineering education past the baccalaureate level. The need for research and teaching assistants may prompt engineering departments to support activities aimed at increasing the number of women who consider graduate education in engineering.

Faculty Recruitment - In addition to programs aimed at graduate education, much attention has been raised lately regarding a shortage of engineering faculty. At the present time only six women are included in an engineering faculty numbering more than 200 at Purdue University. It is the intent of the Women in Engineering Program to be actively involved in encouraging the Schools of Engineering at Purdue to attract and retain highly qualified women faculty members. Hopefully the programs which encourage women students to pursue graduate education will result in a larger pool of potential women faculty members.

Re-entry Programs - The statistics regarding the underutilization of women with mathematics and science degrees points to a rich source of potential students. Due to the location of Purdue University, some distance from a major metropolitan area, such a program would necessarily involve innovation and expansion in the area of courses offered through cable television or remote teaching sites. This is an area that will be given some consideration in future years.

THE CHALLENGE

Much has been accomplished in attracting women students to engineering as a career and retaining them through the earning of a baccalaureate degree. Unfortunately the period of rapid growth has, at best, slowed and much remains to be done. The graphs in Figure 4 reveal how little has actually been achieved in relation to other academic curricula. The need for continued work is obvious and should maintain our active involvement for many years in the future.



Sources: *Earned Degrees* (U.S. Office of Education) and *Summary Report, Doctorate Recipients from U.S. Universities*, 1971-1984, (National Research Council).

Figure 1 Trends in Degrees Awarded to Women

A second chance at science

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Background

In Victoria almost all physical science, technology and mathematics courses at the tertiary level are taught from the assumption that students have completed studies in chemistry, physics and mathematics at the senior secondary level. Students who have taken mathematics and science subjects in the final year of secondary schooling are eligible for consideration for entry to almost all post-secondary courses. Students whose range of subjects excludes these subjects restrict their post-secondary course options by approximately 50 per cent (Firkin and Davidson, 1986). For students who have not completed these subjects there has been no practical path "back into" the sciences.

The majority of students who limit their post-secondary options in this way are female.

Table 1: Female enrolment in some secondary science subjects in Victoria

Subject (Higher School Certificate)	Percentage of candidates who were female (1985)
Physics	26
Computer science	29
Applied mathematics	29
Pure mathematics	33
Chemistry	42

In 1986 Melbourne College of Advanced Education offered, for the first time, a new course designed to provide a re-entry point into the physical sciences and mathematics at a tertiary level. The course is aimed specially at students who had excluded mathematics and physical sciences from their final year or years of secondary schooling.

The two year Associate Diploma in Science is designed for students who have qualified for tertiary entrance in a non-science field. It allows them the opportunity to learn enough physics, chemistry and mathematics for special entry with advanced standing to second year level studies in a science or related degree course at this, or another, post-secondary institution. Special entry provisions apply for mature-age students.

This paper will concentrate on the steps taken in the physical science subjects of the Associate Diploma in Science to ensure females are catered for and supported in their decision to study in an area of strong gender stereotyping.

Structure of the course

Completion of the course requires two years of full-time study or the equivalent. Four subjects are studied in each year. In each year two introductory physical science subjects and one introductory mathematics subject is taken, plus one other science or mathematics subject chosen from the College's standard first year subjects. (The majority of students enrolled in the course in 1986 selected either biology or computer studies. In their second year some students may elect to continue with this subject at second year level.)

By the end of two years full-time study students will have satisfied the requirements of first year tertiary standard in physics, chemistry, mathematics and two other subjects, thus allowing them to change study or career direction.

Physical science in the first year

At some earlier stage most of the students attempting this course have made a decision to actively avoid the physical sciences. So, a course structure which develops confidence and success, and reduces anxiety, is critical.

On the other hand, it is important not only to create an interest in the physical sciences, but to provide the skills and knowledge required to continue with further study in these areas.

Many workers in this area have suggested that students should be allowed less choice of subjects to prevent young women from opting out of the physical sciences (Harding, 1985; Junge, 1985; Smail,1985). On this basis students in the Associate Diploma in Science are not offered any choice of units or topics within the physical sciences.

No specific effort is made to follow students' pre-existing interests. Instead, it is intended that students will be able to develop new interests in the physical sciences following their decision to re-enter science.

One half of the students' time in each year of the course is spent studying the physical sciences. In the first year the two physical science subjects are organized on an integrated and thematic basis. Strong links are developed between themes in the two physical science subjects even though they are taught and assessed independently.

By teaching physics and chemistry as an integrated physical science package students are discouraged from opting out of the study of one, as many females are inclined to do with physics at other levels of education.

Many researchers have documented the lack of experience and confidence of female students in the laboratory and with science equipment (Kahle, 1985; Matyas, 1985). Any student returning to a study of the physical sciences from work or study in a non-science area was anticipated to need special help and support in the laboratory. So a strong emphasis is placed on laboratory work. Two two-hour laboratory-workshop sessions are held every week in each of the two physical science subjects.

These workshops are used not only for the development of laboratory skills and completion of experiments, but for a whole range of different practically-oriented activities such as discussion of outcomes from laboratory work, presentation of seminars and demonstrations by students, group research and project work and design of problem solving experiments. All these different activities are held in the laboratory in order to make it a familiar and comfortable work place. A high level of staff-student interaction in the laboratory allows encouragement of risk taking in less confident students. Co-operative rather than competitive exercises encourage a supportive learning environment.

Although male staff are involved in all aspects of the course, both physical science subjects are run by women, thereby confronting the usual stereotype. Examples and problems used through the lectures, workshops and tutorials make consistent use of girls and women as well as boys and men.

In all of the themes or topics everyday phenomena and real-life applications are used as the starting points for study and as examples. Lectures are scheduled only twice each week (in each subject) and many of these are run as discussions or demonstration sessions. One one-hour small group tutorial is also held each week to encourage participation of those students reluctant to contribute in front of the whole group.

A variety of assessment techniques ensures different skills and styles of learning are all valued and rewarded.

Physical science in the second year

Although some students enrol in the Associate Diploma in Science just to gain a "first base" in science, most expect to use the Associate Diploma to begin further tertiary science or applied science courses, teacher education or laboratory services training. To facilitate the possibility, and success, of change to other institutions for further science study, it is considered important that the second year of the course adopt teaching styles and methods of organization and presentation similar to most other tertiary institutions.

Consequently, in the second year the physical sciences are organized on a discipline basis as one subject of chemistry and one of physics. Considerable overlap with the usual first year subjects chemistry and physics allows many lectures and classes to be taken in common. Each of these subjects is organized into three one-hour lectures, one one-hour tutorial and one three-hour laboratory session per week.

Preliminary evaluation

Because the course ran in 1986 on a pilot basis with about half the number of students expected in 1987 only a preliminary evaluation of its success is presented.

The course was late in receiving permission to begin in 1986 so only minimal advertising of its existence was possible. Offers of places were made through a series of rounds to almost everyone who applied, regardless of whether they met entry prerequisites. Forty-three per cent of applicants were female.

The number of female applicants would be expected to be much higher than this in normal circumstances, given that most of the students who opt out of the physical sciences and mathematics are female. In response, a more widespread advertising campaign has been instituted and a policy of limited affirmative action was devised to increase the proportion of female students. Affirmative action has been found to be unnecessary in 1987 as 60% of students beginning the first year of the course are female.

In 1986 offers of places were accepted by, and the course began with, a total of thirty students. Thirty-seven per cent of students beginning the course were female.

Throughout the year nine of these students discontinued, in two cases for serious health reasons. Several of these students have indicated a wish to repeat the year. Two of the nine students who discontinued were females.

Of the students who began the course a relatively higher proportion of females compared to males completed the year.

Table 2: Student progress in the first year of the course

	Female	Male	Total
Students who began the course:	11 (37%)	19 (63%)	30
Students who continued to the end of first year:	9 (43%)	12 (57%)	21
Students who have stated intentions to proceed to second year of the course in 1987:	7 (44%)	9 (56%)	16
Students who have transferred into other areas of study or training after completing the first year:	2 (40%)	3 (60%)	5

For five students the course has already been a means of entry to other courses. The two young women not continuing to second year of the course are moving into primary teaching in one case and the Navy in the other. In each case they are positive about the benefits their year in the course will have in their chosen futures.

Success rates for male and female students over all their subjects were similar although male students showed a slightly higher tendency to withdraw from one of their subjects. No student who continued with any part of the course withdrew from one or both of the physical science subjects. Male and female students passed and earned distinctions or credits in these subjects in the same proportions.

Both male and female students said they were happy that a variety of assessment methods were used.

Table 3: Student achievement in the first year of the course

	Female	Male
Proportion of all subjects enrolled in, which were successfully completed:	79.4%	81.4%
Average number of subjects taken (out of a possible maximum of four):	3.8	3.6

Male and female students differed in their perception of the structure of the physical science component of the course. Male students saw physical science as one big block while female students said that they were quite aware of a series of distinct themes and units within the two physical science subjects and the links between different topics. Male students expressed the desire for a supplementary course in study techniques and note writing, which will be included in 1987.

The main difference between male and female students' evaluation of the first year of the course related to style of learning. Male students saw the tutorials as a "bit of a waste of time" and expressed a strong preference for more practical work rather than discussion. Female students suggested that the course could be improved by including even more tutorials, more opportunities for discussion and especially discussion in small groups. Although they enjoyed the laboratory work and did not wish to do any less, they felt that it took a lot of time.

When interviewed female students had more definite views of what they had expected when they began the course, and they expected it to be hard.

"I thought it was going to be more difficult when I was reading the course outline, but it's not too hard," one female student said at the end of her first year. Whereas male students' views may be summarised by the statement of one of them, "I didn't know what to expect." Male students expressed little concern at this apparent uncertainty.

The only choice permitted within the course is in the fourth subject students take each year. The majority of students made that choice along stereotypical lines. Twice as many females selected biology as computer studies, vindicating the decision to limit choice in other parts of the course.

Table 4: Additional subject choice

	Female	Male	Total
Biology	6	4	10
Computer studies	3	7	11

Conclusion

Preliminary indications are that young women deciding to re-enter the physical sciences via this course felt supported and encouraged in their decision by the program offered. They were as successful as their male peers and indicated that they believed as much as we did in their own ability and right to study the physical sciences.

In the words of one of the young women, "It's good to have a chance to get back into science."

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CSES and EQUALS: Combining Strategies for Fostering Sex Equity in Math

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Center for Sex Equity in Schools, University of Michigan

The Center for Sex Equity in Schools (CSES) is funded under Title IV of the 1964 U.S. Civil Rights Act to assist school districts in the states of Michigan, Ohio, Indiana, Illinois, Wisconsin, and Minnesota with sex equity initiatives in their schools. It is based at The University of Michigan and works in affiliation with the Program for Education Opportunity, the regional race equity center. Over the past seventeen years, the two centers have offered confidential, free of charge services in equity needs assessment, policy and program planning, curriculum development, staff training and resource identification to several hundred school districts in the region, and equity information to the 3,000 school districts, serving over eight million students in the service area.

CSES services are delivered at three levels of intensity: 1) a single focus newsletter, **Title IX Line** is mailed to each superintendent, sex equity coordinator and all other interested educators in the region several times a year. This effort takes about one quarter of the staff time and budget, 2) a resource center with lending library, speakers' bureau, and referral information is accessible by mail or telephone, to all educators in the region and takes about 15% of staff time and budget and 3) fifty percent of the center's resources go to the most intensive level of service delivery, the selection of a small number of school districts each year for an in-depth long-range intervention, designed to assist the district with the difficult process of planning and carrying out an actual change in the attitudes and values of the institutional culture. A staff member from the center is assigned to work with a designated district liaison and committee of key staff in the district. Together they search for an equity paradigm, a feasible project that will serve as a catalyst for change and a model for future equity work. The CSES staff member will help guide the district committee through the necessary steps of action plan development, resource identification, policy or program implementation, monitoring, evaluation and dissemination. The selection of an appropriate paradigm and attention to the details of group process heightens the changes of success in these interventions.

EQUALS is a project to promote the participation of females and minorities in mathematics. Based at the Lawrence Hall of Science at the University of California, Berkeley, it has developed an exemplary teacher education equity workshop model, classroom activity materials, and support for educators applying the research on occupational attitudes, risk taking strategies, cooperative learning, encouragement and particular skill building needed to foster the success of females and under-represented minority students in mathematics classes and higher paying mathematics dependant careers. EQUALS activities will be presented at a session at GASAT 4. EQUALS stations, less formal activities that can be used in classrooms, staff rooms, and other informal environments will be accessible in the resource and reception areas of the conference.

CSES has used the adoption of EQUALS strategies as a catalyst for equity change in a number of midwestern school districts. Our process has included: 1) the education and motivation of our own staff, 2) the development of a **Title IX Line** issue on sex equity in math, 3) the modification of EQUALs workshops and EQUALS activities to school districts' varying needs and plans and 4) the continued encouragement and support of those educators and districts using EQUALS strategies in the education and motivation of others.

The following items are excerpted from the **Title IX Line** issue on Fostering Sex Equity in Math. The complete twenty page publication, a resource manual on Women, Math and Science, and a specialized bibliography can be obtained through the center and will be available at the conference. Other center publications and model programs focus on student/teacher interaction, women's history, the literature of women and work, comparable worth in schools, vocational education, sexual harassment, and gender and school administration. A list of center publications and

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model programs will also be available at the conference. Educators may also request permission to reprint the information presented here or other publications of the center.

Instructional Strategies for Fostering Girls in Math

In the 13 years since Lucy Sells made the vital connection between sex segregation in the labor force and female students' avoidance of mathematics courses, a number of gifted educators have worked successfully on translating gender and math research results into positive instructional practices and useful teaching materials for elementary and secondary schools. They are designed to counterbalance the forces that influence many young women to discontinue their math studies. Many of them apply elements from recent research on effective instruction and new feminist work on the psychology of women. Their main goals are to foster teacher and student **awareness** of math equity issues, to foster a **climate** in which both females and males learn math skills effectively, to allocate adequate teaching time to the **skill areas** in which each gender has most difficulty, and to provide concrete examples of the **usefulness** of math in future career choices.

Awareness Activities

Gathering and analyzing high school math enrollment information can raise student and teacher awareness of equity issues. So can essays written by students about what they plan to do when they are thirty years old. Their aspirations can be graphed by career area and gender.

Patterns then can be discussed, myths raised and dispelled. Information about why students say they drop math, about how necessary math is for career choices and earning potential, about similarities in male and female math ability in the early grades, and awareness of the influence of past discrimination practices should be presented to students regularly with the goal of creating awareness and conveying the message that they can prepare themselves for a future with more options.

Facts about labor force participation and earning differentials are also influential to students, teachers, and parents.

Instructional Climate

This is probably the single most important area on which to focus attention, as it is often students' attitude toward math rather than their lack of ability that leads to their math avoidance. Many students report that math class is a more rigid and competitive environment than, say, English or Social Studies. True math has its right and wrong answers, but there can be many correct ways to solve a problem, or to find an error in reasoning. Acceptance of **multiple strategies,** emphasis on the **process,** and encouragement of **risk taking** in problem solving are ideal ways of fostering a climate that is more conducive to learning.

Here are some ways to help encourage risk-taking and confidence in problem solving.

Stations are problems placed around the classroom, which students may try at their own pace, often with a partner. They may be left up for several days or weeks to introduce or reinforce a concept, to foster discussion of different problem solving strategies that can be used with them, to help build student vocabulary for talking and thinking about math, and to build intrinsic motivation in math-related activities. They are extremely effective in providing a non-threatening environment for risk taking in problem-solving and should be given their due importance by allotting class-time for them at least once a week.

Cooperative activities use problems that cannot be solved individually, but need the participation of 3-5 students working together. Groups are far more productive than individuals, and this type of problem solving models the interactions actually used in industry and the scientific community. Student achievement particularly in problem solving ability increases considerably with cooperative activities, especially when students are taught peer tutoring behaviors and when they are graded as a group, with a score based on the improvement of all members.

Motivational introductions to lessons are often aimed at getting the attention of the most disruptive students, who are usually male. Introductions that refer to male-oriented sports, emphasize elements of danger, or challenge students to defy the teacher's assertions decrease female involvement in the subsequent lesson. References to popular music, learning to drive, planets, fossils, making things grow are of interest to students of both sexes. Sex-fair classes should use sex neutral topics in motivational introductions.

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Manipulatives are helpful at all levels of instruction. Drawing pictures, moving things around, simplifying, estimating with actual objects all help make mathematical concepts more concrete. Ideally older students should be able to move to abstract levels of thinking, but manipulation can help them understand new concepts or break down difficult problems into understandable components. As with any equipment, manipulatives need to be introduced slowly, with rules for proper use and respect. A sheet of paper which serves as storage area for brightly spray-painted lima beans can help eliminate a classroom mess.

Equal distribution of praise and special help is also of great importance. Male students tend to receive both more praise and more criticism than females, white males receiving up to three times more teacher interaction than Black females. This trend exists in many classrooms, but is particularly prevalent in math classes, where female students often interpret a lack of teacher attention as indicating their lack of ability in the subject area. Programs like TESA (Teacher Expectation and Student Achievement) and GESA (Gender Expectation and Student Achievement) help teachers monitor each other on the praise, rewards, criticism, and individual help that students in their classes receive.

Textbook bias is somewhat less of a problem in newer editions than in the past, but many word problems still have men building things and women forgetting things. Point out to students the harm that is done to girls and boys in perpetuating such stereotypes and making girls feel unwelcome in math. Rewrite or have students rewrite problems using the same concepts but different character attributions. Look at pictures and switch them around. You need not spend much time on this aspect of instruction, but you will get the message across to all students that girls are considered serious students in your class.

Sexual harassment and **powerplays** between students must also be checked. Students who control use of equipment, deface projects, introduce timed competition, or make remarks on student ability are not adding humor or motivation to a classroom. They make the climate decidedly less comfortable for other students, whose reaction is often to retreat or blame themselves for the disturbance.

Calling students to the board, singling them out in front of their peers, or repeated questioning are other behaviors that are particularly uncomfortable for many adolescent girls, unsure of their physical appearance, their right to attract attention and acknowledge a sense of ambition.

Curriculum Content

Standardized achievement tests and research measures show little difference in female and male mathematical knowledge, skills, and understanding until the high school years, when fewer girls are enrolled in math classes. Slight differences exist in spatial relations, estimation, and probability and statistics skills. More sizeable differences exist in solving multi-step word problems and understanding applications of mathematical concepts. An equitable math class needs to emphasize those areas of the curriculum where girls and boys have more difficulty.

The traditional curriculum spends most of its time on accurate calculation. Males and females acquire these skills fairly equally, with females having a slight advantage in the lower grades. Considerably less time is spent on the areas in which girls have more difficulty. Look at how much time you spend on each of those areas. How many pages of your textbook are devoted to them? Boys may gain skills in these areas outside of school in the type of play activities and projects they are more likely to do with family members. Girls are more school dependent for learning them.

Spatial relations are an important part of all kinds of problem solving: visualizing simple arithmetic concepts, understanding geometry, using tools, building and fixing things. Spatial relations should be a major part of the early childhood curriculum and should continue throughout the math sequence. Manipulatives and cooperative work are the best methods for teaching them.

Estimation and measurement are also best taught through hands-on activities, and should get more attention in a sex-fair curriculum. A student's ability to estimate is a key factor in her/his confidence.

Multi-step word problem solving skills and applications ability grow directly out of students' confidence. Only with a vocabulary for discussing math concepts, a variety of problem solving strategies, and an ability to assess probable right and wrong answers, can students have the framework for solving complex problems. Using stories with mathematical themes is an excellent way to build application skills. Programs that encourage mathematical reasoning in other content areas are also valuable. Social studies classes can be encouraged to collect, organize and interprete statistical data, English classes can read and write mystery-type problem solving stories.

Usefulness of Math Role Models

Many young women claim to drop math and science classes because they see no use for them. This attitude often stems from a lack of understanding that they will work in their adult lives, that they don't know how much math is needed for many jobs, that they have not been exposed to traditional and nontraditional career options, that they are unaware of the pay advantages in technical and scientific fields. Many students feel they have no control over their future worklives.

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The schools most successful in fostering girls in math and science build career components into their math and science classes. Teachers provide information about traditional and nontraditional fields, the amount of math needed for specific jobs, the skills used in different jobs, the salaries in the workforce and how specific skill areas relate to jobs. Most effective is the use of role models, inviting nontraditional young workers of both sexes to talk to students about their work. They can provide the most accurate information about their training, the skills they use, and the salary they receive. Students react particularly well to workers' accounts of who helped encourage them, how they did in school (they were usually not straight-A students), and how they lead regular lives outside of work. Younger students especially enjoy learning to use a specialized tool or piece of equipment used by a nontraditional worker.

Many strategies are available to us to help encourage all students in the studv of math. Which ones are you using?

Marketing Your Math Courses With Equity In Mind

Jingles praising math on top 40 stations. Multicolored coupons to shorten homework assignments. Multiplication problems on purple banners. Famous female mathematician stickers. All of these are promotional gimmicks to inform students about math, perhaps increase their motivation to learn math, and attempt to influence their behavior to take math. Are they worth it? Will they work? Realistically, what can a school do to effectively market math classes to male and female students?

Marketing is the coordinated system of activities involved in the moving of goods and services from the producer to the customer. It includes the development of the product, the pricing, packaging, and carefully defined promotional campaign. Here the product is effective math instruction, and the marketing strategy will be a planned course of action toward bringing an increased number of female students into math classes.

The Key to Marketing

Marketing involves bringing the right product, at the right price, in the right place, with the right promotion, done by the right people, to the right target audience. The time you take to define each of these aspects of your marketing campaign will help you focus your energies and resources toward getting the right message to the right people.

First define your **product**. Is it all math courses? Do you want to focus particularly on the first course students can elect? Do you want to generate excitement for a course just before that first choice?

Can you vouch for the **quality** of that product? Is it **geared** toward the **market** you intend? The article on p. 8 will tell you more about how to create math classes that are more responsive to girls' learning needs. But just changing your product will not automatically bring your new students in.

Your choice of specific courses to market will start to define your possible audience. Is it large enough that changing only a portion of the group will make a difference? Is it too large to have a unified message? Is that group reachable by you or someone you hire? Is there at least a chance they will be responsive? Marketing physics or advanced math classes to girls may not be worth your effort if you had only a few girls in the prerequisite courses. But marketing math in general may confuse you in trying to reach twelve year olds and eighteen olds with the same message. Your market should be of manageable size to the resources of your campaign, and your product should be specific to that market. Find out as much as you can about who they are, what they like, what they think of your product, and why they haven't wanted it in the past. The research on girls and math should help you signficantly with this aspect of your work.

Price

We often don't think of free, public education as having a price, but it does. Will students get adequate credit for the time they put in? Will the course conflict with something else they may want to take? What kind of pressure will they have to take from peers or family? How might it affect their self image? Their after school job? Have a clear idea of what the student's cost may be. If possible reduce those costs through rescheduling, support groups, peer and family education. But also include in your message that quality products are often expensive, though worth the added price. Address the price issue directly in your marketing campaign.

Place

The physical locale for your classes is also important. See that it is in an attractive area and that students are made aware of that Remember kindergarten trips to first grade, or free lessons to get you to visit the health spa? The room itself should have motivating materials and attractive posters of people of both sexes. A class at the remote end of the building, a location where students of only one sex congregate, a traffic pattern that may

expose students to sexual harassment can discourage enrollment. Course fairs and orientation meetings should be in pleasant surroundings and should show people the attractiveness of the actual classroom to be used. Locale can often signal a school's commitment, or lack of real commitment to equity.

Your choice of **promotion medium** may well be the biggest decision you have to make. Given your audience and your product, what will work best? Word of mouth? Posters? Fliers? Assembly programs? Radio? Frisbees? Hats? Bookcovers? Shoelaces? Banners? Marketing researchers specialize in defining effective media for different segments of the population. Advertising companies have lists of promotional items. Get an advisory group together and ask them what will sway your group. Teenage girls are often fond of music, posters and clothing related items, so try using them to convey your message, or draw them as symbols in your campaign. Your medium should closely fit your message. It can be serious and enduring (invest in your future), playing on students' uncertainty (keep your options open) stressing the interactional (math is a team sport), intrinsic interest of math (a geometric puzzle as logo), heightened esteem of good math students, or the status of being nontraditional. Make sure your audience will believe your message and that you convey it clearly. Have recognizable graphics and repeat your message frequently.

Who delivers your message is also very important, for that person conveys the value of your program. Your spokesperson should be knowledgeable, friendly and confidence-inspiring to your audience. Teenagers report they are swayed most by peers in their course choices, then by parents and other adults they know well. Teachers are decidedly less influential, and counselors have the least influence of all. Letting well-regarded students talk about their own experiences may be one of the most powerful marketing devices. Remember to pick students a little older than your target group, from both sexes and different racial and ethnic backgrounds. Encourage your message givers to be realistic about what they found difficult, who helped them, and what kept them going, as well as letting them relate their enthusiasm for math, the career they're embarking on, the salary they make, or the independence they feel. If you choose older role models, make sure students find them attractive, "normal" people with whom they could share mutual interests. Be continually aware of many students' fear of becoming the crazy scientist or the homely brain.

Role model panels, course fairs, class visits, prizes, giveaways, course catalogues, contests, social events, and support groups and clubs are all possible marketing devices. Make sure to take advantage of the all-important influence of word-of-mouth. Many of these promotional activities have existed in schools for years, but they've been targeted at a white male audience. Now it's time to rethink them and target them more equitably. Set yourself a modest goal for the first year, then refine your campaign as you become more knowledgeable in what works. Create an event, a tradition, and eventually an institution. Broaden your horizons and those of your students. Market math!

ESTABLISHING SUPPORT GROUPS FOR GIRLS IN MATH, SCIENCE AND COMPUTERS

This newsletter has already mentioned that the above three areas are considered nontraditional areas of study for girls. Survival of people joining an area which is not theirs by tradition is made easier if there is a support group, study group, or special club. Such a group can also be used as an effective strategy for the recruitment of new members as has been shown in numerous projects in vocational education. This article will address itself to some of the steps that should be followed by an equity advocate within the schools in establishing a support group for nontraditional students: specifically, for girls enrolled in advanced math, science, and computers.

Step 1: Consult with and get the support of your administrator, teachers, and counsellors. Write to them, talk to them personally and have them come to the first meeting of the formation of the support group. Always talk about how all groups that want to bring about change in individual behavior and attitude use the strategy of support groups. You can cite examples from vocational education, Alcoholics Anonymous and drug rehabilitation programs, and college programs to help older returning students.

As for rationale, be sure to say that such a group will be cost effective by giving more time to the school counsellor to deal with other students and other matters. Make sure that the people you are talking with do not misunderstand this to mean that it will replace individual counselling. It is cost effective because problems arising from being a nontraditional student will be addressed in a group format rather than one on one.

At this stage in the process focus primarily on alleviating the fear and anxiety of teachers and counsellors. Let them know that you are on their side. All you are trying to do is make their job easier by spotting trouble before it becomes explosive. Show them that the support group is there to help facilitate a smoother transition.

Step 2: Invite administrators, teachers, counselors, and others to a planning meeting. Give feedback of this meeting and information about follow-up to all those who came, as well as those who did not. This will show both groups that you are serious about this endeavor and that it is going to materialize.

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Step 3: If possible, announce the first support group meeting before recruitment and/or course selection is complete. Have a brochure ready that can be given to students at this time. Give copies of this brochure to teachers, counsellors, recruiting and admission officers. Students who select a nontraditional course of study feel more comfortable if they know beforehand that there are other students like them.

Step 4: Once you have the names of your nontraditional students, contact them by letter a few weeks before school begins. In this letter mention the fact that they are to be admired for signing up for these courses. Suggest that the group or club will help them even more. Mention the date and time of the first meeting, where it is going to be, and who to contact. Give your name, office number and times when you can be reached. If there is time and money, call them a few days before school begins as a follow-up and reminder.

Step 5: As much as possible, make sure that group facilitators are of different race and ethnicity. If you have nontraditional students of both genders, try to have a facilitator of each sex.

Step 6: Schedule the first meeting for the first week that school begins. Take into special consideration the period of allowable course changes. This is when nontraditional students are most vulnerable. During this time, post notices for meetings in all visible places. Insert them in newspapers, ask teachers, counsellors and others to make announcements of meetings.

Step 7: Begin the first meeting with a pep talk about students' courage and commitment to select nontraditional areas of study. Mention to them that they may not feel comfortable with all teachers and fellow students but that the support group will help them deal with these issues. Tell the students that they should be prepared to do all their work but that the group may help them study better. You should also make sure the students know that the support group will not change rules and requirements unless it is established that such rules and requirements are sex-biased. Mention that the support group can mediate with teachers, administrators, counsellors and students about their biased behavior and, among other things, may be able to arrange for tutorial help.

Step 8: Close the session with another pep talk and announce the location and time of the next meeting. Schedule this meeting for at least two weeks after the first meeting. Instruct the students to come with some issues and problems to discuss. These could be what has happened to them within those two weeks or what they think will happen. Make sure that the students understand that if they encounter any difficulties before the scheduled meeting that they can contact you or any of the other facilitators. Also mention that at other sessions speakers will be available who have dealt with the same issues themselves. They could be working in math, science, or computers, or any other nontraditional area. This is especially helpful at sessions when students do not have much to say.

Step 9: As a facilitator, go back to the administrators and tell them how the group is going. Show them how helpful it is. Consider inviting them as speakers. You could also consider inviting other teachers, counsellors, or students.

Step 10: Evaluate the program by asking students how the support group is helping them, and by keeping enrollment and drop-out data. You will need specific documentation to win approval for continuing and expanding the support program, and to recruit new students. Start collecting it from the beginning.

Step 11: If the number of girls in math, science, and computers is not enough to form a support group, have the girls enrolled for these courses join another support group formed for nontraditional students. Hopefully, there are students in other nontraditional areas. BUT HAVE A SUPPORT GROUP one way or another.

What Administrators Can Do to Foster Girls in Math

Effective schools research points most decidedly to the principal's crucial role in promoting student achievement. The principal, department chair, or curriculum coordinator who leads a sex equity effort in mathematics will:

- Have a basic understanding of the instructional strategies that foster girls in mathematics.
- Promote awareness by gathering and disseminating enrollment information in a secondary school, and standardized test score item analyses by problem type and gender.
- Make time and resources available for awareness-building activities for teachers, counselors, parents and students.
- Support staff development in math equity to help promote equitable teaching strategies and curriculum.
- Allocate budget for manipulatives, and other problem solving educational materials.
- Support staff development for other subject teachers who suffer from math avoidance, to help them promote math related activities and positive attitudes in their classrooms.
- Ensure that award criteria, club strategies and other forms of mathematics recognition are consistent with the principles of an equitable climate.
- Include equitable teaching strategies in teacher and administrator evaluation and accountability.
- Support the formation of networks for students and teachers to help foster girls in math and science.

Recommended Resources on Girls and Math

Research

Armstrong, J. M. "Achievement and Participation of Women in Mathematics," **Journal for Research in Mathematics Education** 12 (1981): 356-372.

Eccles-Parsons, J., et al. "Attributions and Academic Choice: Origins and Change," in **NIE Annual Report**. Washington, D.C.: National Institute of Education, 1979.

Eccles-Parsons, J., et al. "Socialization of Achievement Attitudes and Beliefs: Classroom Influences",**Child Development** 53 (1982): 322-354.

Eccles-Parsons, J., et al. " Socialization of Achievement Attitudes and Beliefs: Parental Influences," **Child Development** 53 (1982): 310-321.

Fennema, E., and Sherman, J. "Sex-related Differences in Mathematics Achievement, Spatial Visualization and Affective Factors," **American Educational Research Journal** 14 (1977): 51-71.

Fox, L. S. "The Effects of Sex Role Socialization on Mathematics Participation and Achievement," **Women and Mathematics: Research Perspectives for Change**, NIE Papers in Education and Work. No. 8. Washington D.C.: National Institute of Education, 1977.

Jacobs J. and Eccles-Parsons, J. "Science and the Media: Benbow and Stanley Revisited," University of Michigan, 1983 (report).

Kahle, J. B. "The Disadvantaged Majority: Science Education for Women," Burlington, N.C.: (Carolina Biological Supply Company), 1983.

Maccoby, E. and Jacklin, C. **The Psychology of Sex Differences.** Stanford: Stanford University Press, 1974.

Pedro, J.P., Wolleat, P., Fennema, E., and Becker, A.D. "Election of High School Mathematics by Female and Males: Attributions and Attitudes," **American Educational Research Journal** 18 (1981): 207-218.

Trowbridge, L. W., et al. **Becoming a Secondary School Teacher**. Columbus, OH: Charles E. Merrill, 1981.

Vockell, E. L. and Lobbone, S. "Sex-Role Stereotyping by High School Females in Science," **Journal of Research in Science Teaching** 18 (1981): 209-219.

Curriculum Materials

Burns, Marilyn. **Math for Smarty Pants.** Palo Alto: Creative Publications. Grades 4-8. $6.95. Stories, activities, problem solving in this book and several others in this series.

Downie, D., Slesnick, T., and Stenmark, J. **Math for Girls and Other Problem Solvers.** University of California-Berkeley: 1981. Elementary school level curriculum activities. Emphasis on problem solving activities: logic and patterns; breaking set; creative thinking, estimating, and observing; and spatial visualization. $7.50. Order from EQUALS. See Organizational Resources.

Fraser, Sherry, et al. **SPACES: Solving Problems of Access to Careers in Engineering and Science.** Palo Alto, CA: Dale Seymour Publications, 1982. Activities for students in grades 4-10, about scientific careers; problem solving skills; attitudes toward math; spatial visualization skills; and work with mechanical tools. $10.00. Order from EQUALS. See Organizational Resources.

How High the Sky? How Far the Moon? An Educational Program for Girls and Women in Math and Science. Newton, MA: WEEA Publishing Center, 1982. Short exercises for K-12 students on problem solving skills and career information. $14.50. Order from WEEA. See Organizational Resources.

Science Career Programs. Research Triangle Park, NC: Research Triangle Institute. 1982. National Science Foundation sponsored program to encourage females and minorities in grades 4-9. Information about skills, careers, salaries in format useable with students. Accompanying filmstrip and poster set.

For Educators

Beane, Diana Banks. **Mathematics and Science: Critical Filters for the Future of Minority Students.** Washington, D.C.: MidAtlantic Center for Race Equity, 1985.

Brush, Lorelei R. **Encouraging Girls in Mathematics: The Problem and the Solution.** Cambridge, MA: Abt Books, 1980. Summary of research and major recommendations for change.

Cheek, Helen Neely, et al. **Handbook for Conducting Equity Activities on Mathematics Education.** Washington, D.C.: National Council of Teachers of Mathematics, 1984.

Expanding Your Horizons in Science and Mathematics: A Handbook for Planners. Newton, MA: WEEA Publishing Center, 1980. Describes how to plan, conduct, and evaluate conferences to increase young women's interest in mathematics and science. Order from WEEA.

Fennema, Elizabeth, et al. **Multiplying Options and Subtracting Bias.** Reston, VA: National Council of Teachers of Mathematics, 1981. Materials for developing and presenting workshops on women and mathematics to junior and senior high school students, school counselors, parents and science and mathematics teachers. Four versions of a videotape of the same title.

Kaseberg, A., Kreinberg, N., and Downie, D. **Use EQUALS to Promote the Participation of Women in Mathematics.** University of California-Berkeley: 1980. Describes the EQUALS Teacher Education Program, designed to promote sex-fair mathematics instruction and counseling. Provides methods, and materials for K-12 use, bibliographies.

Tobias, Sheila. **Overcoming Math Anxiety.** Boston: Houghton Mifflin Co., 1973. A modern classic, particularly helpful in assisting teachers to recognize their own math avoidance, and how they may convey messages about it to their students.

Mostly for Families.

Skolnick, J., et al. **How to Encourage Girls in Math and Science: Strategies for Parents and Educators.** Englewood Cliffs, NJ: Prentice-Hall, 1982.

Thompson, Virginia, et al. **Family Math.** Berkeley, CA: To be published 1986. Strategies for workshops for parents and children together. $15.00 plus $1.00 shipping from EQUALS.

Role Model Videotapes

Nothing But Options. Oakland, California: Math/Science Resource Center, 1984. Environmental scientist; systems analyst; electrical engineer; financial investment counselor, and computer graphics designer. Upbeat presentation. Could be used with junior high, high school, or adult audiences. 17-1/2 minutes. $40 rental, $240 purchase.

Math/Science Resource Center
Mills College
Oakland, CA 94613
(415) 430-2230.

Options Unlimited: Women in Technology Videotapes. Consortium for Educational Equity. Rutgers University, New Brunswick, NJ. (201) 932-2071. Two half-hour videotapes each featuring five women in rewarding careers.

Sandra, Zella, Dee, and Claire: Four Women in Science. A film for students in grades 7-12, exploring the work and lives of an astronomer, a mechanical engineer, a veterinarian, and a laser physicist. Available with **Expanding Your Horizons** book, WEEA Publishing Center.

Science: Women's Work. National Science Foundation, 1982. Half hour 16mm sound and color film. Geologist, astronomer, marine biologist, and other women interviewed. Free from:

Modern Talking Picture Service
21421 Hilltop St. #23
Southfield, MI
(313) 352-2780

Women in Science. School of Dentistry, University of Michigan, 1983. Series of videotapes mostly for high school students, available in several formats for purchase or rental. Includes videotapes on women in dentistry, engineering, chemistry, computer science, geology, biomedical science, physics/astronomy, and the dilemma of deciding what to do. Available from:

Women in Science
B322, School of Dentistry
University of Michigan
Ann Arbor, MI 48109
(313) 763-3337

Some Maths/Science Intervention Programmes in New Zealand

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Summary

In response to the well recognised need for more participation by women in the scientific field several new intervention programmes have been developed recently in Auckland, NZ. They are designed both, to increase women's awareness of opportunities in science, computing, and mathematics related occupations and, to encourage girls to continue to study these subjects through upper high school and tertiary educational levels.

Early in 1985 a new organisation, Auckland EQUALS: Maths/Science Network, was formed. This voluntary group, composed mainly of teachers from a variety of educational institutions, currently has a membership approaching one hundred. Throughout the country it is having a direct influence at all levels of schooling on the teaching of mathematics, science and computer studies.

At Auckland University, in 1985, some members from the Departments of Computer Science, Mathematics and Statistics, Physics and Engineering Science felt that positive action could be taken to increase awareness of careers stemming from a degree in one of the mathematical sciences. Recognising that actual career paths for graduates with these types of degrees are likely to overlap, they collaborated to organise a one day seminar at the University to present to two hundred and fifty prospective female students, teachers and careers advisers a wide range of possible career opportunities. Teacher and participant evaluations of the day were generally strongly positive, consequently the seminar was repeated in 1986.

Early in 1986 a national workshop was held in Auckland with the general aim of bringing together people, from throughout NZ, concerned with the direction science and technology are taking. It was planned as a forum for people working towards equal opportunities for all in science and technology.

New Zealand Background

Over the past two decades there has been considerable research worldwide to isolate factors which influence women's decisions to avoid mathematically related scientific areas. Stewart (1981) summarizes most of the overseas research and gives statistics of the position of girls in secondary and tertiary education in NZ, then Wily (1982) gives an historical development of projects in NZ concerned with gender and mathematics. Bell (1986) discusses the reasons for the alienation of girls from science with reference to NZ and overseas research.

Wily (1986) analyses the NZ students' pure mathematics portion of the data collected in 1981 by the International Association for Evaluation in Educational Achievement (IEA), and demonstrates a repetition of patterns observed overseas regarding competence by each sex in different areas of mathematics. This is also shown by Reilly, et al (1987) in a question by question analysis by sex of the national 1985 Bursaries Pure Mathematics examination taken at the end of high school. A second classification of performance on the basis of school type, coeducational or single sex, was inconclusive. Weatherburn (1987a) describes gender differences in achieving understanding in chemistry; girls through discussions with teachers and friends, and boys through researching on their own.

Castina and Clare (1985) investigate the career aspirations of high school girls and their recommendations include special encouragement of girls in non-traditional subjects and the inclusion of more career education in the classroom. Trends in formal vocational training for women in NZ are discussed by Welch (1984), who suggests that appropriate interventions will need to be diverse, ranging from inservice training for science teachers to financial incentives for private sector employers taking on female apprentices.

Bradford, Fenwick and Suuring (1985) provide statistics about NZ women in the non-traditional workforce and give a description of some strategies to increase the numbers of girls training for non-traditional technical jobs, for example, the nationwide "Girls can do Anything" campaign. Weatherburn (1987b) describes how a resource group for teachers and support network for women working or wanting to work in science were established in Wellington, NZ.

Auckland EQUALS: Maths/Science Network

This organisation was formed early in 1985 with the following aims and objectives.

AIMS.

1. **To increase girls' participation in and enjoyment of maths/science/computing courses.**
2. **To increase women's participation in and parents' awareness of careers involving maths, science and computing.**
3. **To increase teachers' awareness of sexism and cultural bias in the classroom.**
4. **To provide support for teachers with the above concerns.**

OBJECTIVES.

1. **Primary and secondary teacher in-service programmes introducing activities to encourage girls in the above areas.**
2. **Day conferences for Intermediate and Secondary school girls to provide access to career information and exposure to role models in maths/ science/computing based careers.**
3. **"Maths without Fear", "Computers without Fear" courses for women in the community or in tertiary education.**
4. **A resource library.**

A core group of ten people meets monthly, general meetings for all members are held once a term, and in-service days have been held to develop new curriculum materials and general awareness material for parents. Members are kept informed of activities, coming events and resource materials through periodic mailouts, contact with similar groups in the USA, Britain and Australia is maintained.

General meetings usually comprise :

(i) a short talk, e.g. on the current participation of girls in maths/science courses in NZ, research findings on girls' abilities in these areas, overseas maths/science intervention programmes, the International Girls and Science and Technology (GASAT3) Conference in London, peer tutoring in maths, poetry as a way of enriching maths lessons;

(ii) a woman role model working in areas such as geophysics, nuclear physics, oceanography, operations research and food technology describing her respective work and career path;

and

(iii) division into small groups to try out maths/science co-operative problem solving activities designed to improve logical thinking and spatial skills and to make the classroom atmosphere less competitive.

In response to a request from the Department of Education, maths and science teachers from the core group have written resource materials for nationwide distribution. The science teachers have started long term work on the science curriculum, trying to make it more "girl friendly". They also produced a booklet which showed the low percentage of young women taking senior high school sciences, offered suggestions on how to encourage girls into science classes and contained a questionnaire for teachers to cònsider how sexist their approach might be. The maths teachers in the core group have written material on responsible decision making in the classroom, using activities and games to develop logical and spatial skills, co-operative problem solving and career information for parents of girls studying maths. This group also contributed a Women and Maths section to "Maths Discussion Starters" (a resource booklet for teacher development programmmes). These new materials have been presented to other teachers during workshops at teacher in-service days.

Seminar on Careers in the Mathematical Sciences

This second intervention programme, a one day seminar held in 1985 and 1986, targets a smaller group than EQUALS. It is aimed at senior female high school students who, by their subject choices, have already demonstrated an interest in maths and science. The objectives were:

1. **To inform prospective women students of the career openings available to them after training in the mathematical sciences, by hearing directly from women in such careers.**
2. **To have them meet, question and talk with these women in an informal setting, including the opportunity for one-to-one discussion.**
3. **To develop the self-confidence which comes from knowledge, so that they are equipped to make use of their various gifts and abilities to the full.**

All high schools in the Auckland area with senior female students were notified of the seminar and invited to send a small group to participate the response to which has been overwhelming. Teachers and careers advisers were particularly encouraged to attend the seminar, and an effort was made also to reach mature women contemplating university study.

The Mayor of Auckland, Dame Catherine Tizard, opened both seminars with an address concerning the need for more women to obtain tertiary education in order to be well prepared for possible career opportunities. A panel consisting of women with careers in scientific fields then gave short descriptions of their own backgrounds and career paths.

During the day the girls were taken on tours of the contributing departments, which had a variety of displays for the participants to try and role models for the girls to talk with. All participants were provided with a handout of brief biographical details of the role models. In the choice of role models every effort was made to attain an overall balance of age, race, marital status, subject matter and work experience outside NZ; many had combined several disciplines or crossed from one discipline to another, some worked at home, several had left the work force and had returned after a number of years, others were in job sharing or part-time positions. Current female university students assisted with the displays which had a two-fold benefit; participants often felt more comfortable questioning people closer to their own age and the university students took the opportunity to broaden their own career knowledge by talking with the role models.

For one period of the day the teachers and careers advisers attended a special discussion about careers. The closing session of the seminar consisted of a brief talk on vocational guidance outlining the way to obtain further information on careers in mathematical sciences.

Each year registration and evaluation forms were completed by the participants, which in 1986 indicated that all the girls were taking mathematics and some combination of chemistry, physics and commerce at school. Their ethnic origins were Maori (4), Polynesian (9), Asian (22) and Caucasian (138) and just over one third were from single sex schools. All were planning some form of tertiary education. The answer to the question on the 1986 participants' registration form : **'Why do you think girls don't take advanced maths and science courses?'** were interpreted as falling in the following categories:

Society doesn't expect girls to take these subjects	63
Some girls think these subjects are too difficult	44
Girls are not encouraged to do these subjects	33
Girls don't realise these subjects lead to likeable jobs	24
Some girls don't like these subjects	19
Girls don't understand what these subjects are about	8

To quote a few specific replies:

'Girls prefer to stick to traditional courses and/or they find a general understanding of mathematical and scientific courses hard to come by'

'It is not done for girls to be more intelligent than boys'

'Because they are not made aware that the courses are interesting and lead onto interesting careers' .

On the evaluation forms the displays provoked the most comment, obviously those in different departments appealed to different girls and possibly the most difficult task for the organising committee is creating displays that are both relevant and easily understood. Some of the role models helped by bringing material that was pertinent to their work. There were several requests for more 'hands on' displays and more time to explore the ones they particularly liked. (Because of the spreadout locations of the four departments involved and space restrictions within them it was necessary to divide the girls into groups that were rotated on a preset schedule.)

There were requests for more handout material on careers and details of specific courses that should be taken to prepare for a particular career. From one realistic student:

'The monetary aspect of employment is never discussed. I feel that this is very important, especially considering the number of training years and the total number of years in the workforce'.

Out of a maximum ranking of 5 most girls gave the seminar a 4 and agreed that they had finished the day with a much better knowledge of possible job opportunities. Many heard of some careers for the first time (actuarial work, geophysics, practical statistics, medical physics and operations research were mentioned most) and stated that they wanted to investigate them further. While it is impossible to determine precisely the impact of seminars of this type, comments like the following encourage the thought that they should be continued:

'I don't regret coming because I've learnt things for and against certain topics'

'I found the seminar quite fascinating and it has confirmed my aims of a future career in the maths/sciences' .

While the teachers themselves found the seminar personalised, informal and relaxed some felt that the school students were somewhat daunted by the high qualifications of many of the role models. They commented on the continuing extra effort needed to encourage girls to study maths and science; in particular girls need contact with role models and to receive appropriate career information which should be shared with their parents. Many teachers felt uninformed about the wide variety of possible careers and were most appreciative of the opportunity to receive so much personal knowledge first-hand at the seminar.

'All very relevant information, I feel that I'm far better able to advise students and direct them towards relevant careers'

Many of the role models mentioned they were just 'feeling their way', not really knowing what was expected of them. Most found the experience worthwhile and would be willing to participate again, continuing to help us experiment until we find the best format for relaxed interaction between them and the other participants.

Judging by the general feeling on the days and the evaluation response from those attending, the organising committee feels that the seminars were well balanced, worthwhile, and achieved their objectives to a considerable degree. More seminars of this type are planned for the future.

WIMMSET

This national workshop took place in Auckland during a weekend in February, 1986. Entitled "Women in Maths, Medicine, Science, Engineering and Technology" (WIMMSET), the workshop was timed to coincide with the visit of Dr Jan Harding from the Centre for Science and Maths Education, Chelsea College, University of London. The weekend workshop was organised as a cooperative venture by interested women working in science and engineering, and women from the Maori and Pacific Island communities.

One aim of the weekend was to bring together people from throughout the country who are concerned about the directions science and technology are taking, many people have expressed the concern that as society becomes increasingly complex so technology appears to become more masculinized with emphasis on control and profit making and divorced from the real needs of people. At the workshop the sentiment that social organisation for human development should come first and the technology should follow was expressed and furthermore science should make use of different ways of knowing and creative thinking. Female values often express a more global involvement with human issues (Vines, 1985) and a greater number of women working within science and technology would enable them to reflect these values .

A special effort was made to attract people with experience and knowledge gained outside any formal educational system, as well as within, so as to include as many different perspectives as possible. A special grant from the Ministry of Women's Affairs enabled some of these people to travel to Auckland. Nearly 70 people from many parts of NZ participated in workshops.

Among the topics discussed were Holistic Health; Ethics of Science/Medicine; Religion, Spirituality & Science; Politics of Control in Science and Technology; Maths/Science Education and Women; Technology and Minority Ethnic Groups; Traditional Ethnic Medicines ; Science for Everybody; In Vitro Fertilisation; Careers and Children; Maths/Science/Technology Anxiety; Female Stress. A report of WIMMSET is available from the authors of this paper.

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Operation SMART: From research to program--and back

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Girls Clubs of America, Inc.

Summary

Operation SMART--"Science, Math, and Relevant Technology"--is a major initiative of Girls Clubs of America, Inc. (GCA), a national organization with 240 Club centers across the United States. Its purpose is to encourage girls to participate in math and science during their school years and as they plan careers. In partnership with GCA, seven local Girls Clubs in Massachusetts and New York are designing model programs of informal education for use by Girls Clubs and other youth serving organizations.

The first Girls Clubs were formed over one hundred years ago during the Industrial Revolution for the young women who worked in the factories of the northeast mill towns, and for the daughters of the factory workers. A century later, Operation SMART is GCA's response to the technological revolution, to women's changing role in the labor market, and to the needs of the 250,000 girls we serve each year. Nearly two-thirds of participating girls are from families with incomes under $15,000, and close to half are members of minority groups. They face an educational and employment system that presents often overwhelming barriers to access and opportunity.

The Operation SMART program was designed after an extensive review of the research. Ongoing program development makes constant reference to the latest findings about strategies for involving girls--especially those from minority and low-income backgrounds. Operation SMART has been effective in large part because the research guided us to successful interventions. (Beane, 1985; Casserly, 1983; *The Computing Teacher*, 1984; Kahle, 1984; Lockheed and Harris, 1982; Lockheed, 1985; Malcom et al, 1984; Matthews, 1983.)

The cycle that began with our review of the research continues. The questions the project generates are as important as the solutions and approaches we develop. Issues and dilemmas raised during the project's first year--such as how different from school should SMART be, how can fun experiences in the Club carry over to girls' decisions about education and careers, and what encourages innovation and improvement in math and science education--led to the initiation of the Operation SMART research project.

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Through telephone interviews, case studies, and a conference of "experts," we concluded that, above all else, we must to find ways to give girls a coherent message that math and science are for them. The second phase of the research will take an intensive look at girls in Operation SMART, examining the messages they get at the Club, at home, in school, in outside activities, and from the local and national media. We will also develop a "tool kit" of research and evaluation measures--brief, fun, challenging activities that engage girls in measuring their own and each others' attitudes and participation in math, science, and technology.

The Operation SMART Model and the Research On Which It Is Based

The goal of Operation SMART is to help girls acquire an attitude of scientific inquiry toward everything they do. Operation SMART challenges girls to question, observe, record, watch for changes, estimate, make mistakes, try again, take physical and intellectual risks, get messy, take things apart, dissect, analyze, organize, look for patterns--and most important, to be skeptics and not take anything for granted.

The Operation SMART model has "six easy pieces," including scientific inquiry, an approach that pervades the entire program; scheduled sessions in science, math, and technology for small groups of girls, held once or twice a week for an hour or more; incorporation of math and science and an attitude of scientific inquiry in all Club activities and policies; career exploration; family involvement; and community connections, to increase girls' access to resources, and to help in program development.

Each of these components has a strong research or experiential base that constantly informs program development. For example, we focused on scientific inquiry as we reviewed the literature about sex-role stereotyping and girls' access to math and science programs. We considered how social norms shape expectations for girls, and how girls get less exposure to scientific equipment and to the spatial and risk-taking play experiences that help boys to feel comfortable in math and science. (Fennema, 1977; Fennema and Sherman, 1977; Haertel et al, 1981; Miura and Hess, 1983; Lever, 1976; Reid and Stephens, 1985.)

We thought about the qualities of a scientist, such as the ability to generate questions, to concentrate on one's work and ignore outside distractions, to wrestle with uncertainty and tolerate creative chaos, to experiment and analyze both failures and successes, to have the courage to try new and alternative approaches. And we posited that girls' socialization in this culture, where girls and women are valued for being neat and pleasing others, not making mistakes, responding to others' needs before their own, and subordinating or postponing personal goals, inhibits the development of the qualities that promote scientific pursuit. Our answer to the limiting social factors was scientific inquiry, an approach that encourages questioning, exploration, discovery, and taking risks.

We set aside time for girls to try out science and math in new ways during the scheduled sessions held regularly at each of the model Clubs. We encouraged all Club staff to incorporate scientific inquiry and a questioning approach into the programs they conduct with girls. We also focused on the norms and policies of the Club: are girls rewarded for appearance, for being quiet and obedient? What if they are completely engaged in observing the ant farm, or building in the shop? How do adults respond?

We drew on the work of EQUALS and Children's Television Workshop, among others, and emphasized hands-on, fun, and purposeful activity that played down competition and played up cooperation and group problem-solving. We stressed the use of tools and equipment, physical experience, and process over product.

On a typical afternoon or evening, SMART girls might take apart machines, examine everything from sand to pennies to fingerprints under microscopes, look through telescopes, dissect abandoned birds nests, build replicas of their Club and their towns, dig up earthworms, open up computers and photocopy machines to see how they work, use tools to fix their bicycles and figure out what makes the wheels go round and the gears operate, experiment with ice and insulation, build their own cameras, use video equipment, or take a simulated canoe trip on the computer.

Offering girls fun and educational experiences in math and science is clearly a centerpiece of Operation SMART, but deals only with the present. Decisions made during a few short years of adolescence have distressingly long-term economic implications for girls' futures (Coalition on Women and the Budget, 1983; National Commission on Working Women; Tittle, 1981; Shapiro and Crowley, 1982). We know that math and science serve as a "critical filter," (Beane, 1985; Peng et al, 1981; Sells, 1973), and that girls who do not pursue these courses eliminate a whole range of career opportunities, especially jobs that are nontraditional, better-paying, and offer the possibility of advancement. The focus of Operation SMART has to be on helping girls keep their career and educational options open.

How can you persuade girls to enroll in math and science courses in school --courses that may well be boring in a sexist atmosphere that makes them feel uncomfortable? How can you overcome the stereotypes that girls bring with them about what are or are not appropriate roles for women? How do you get girls to imagine the future--their futures--and envision

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possibilities when they have no experience on which to draw?

Visits to workplaces, contact with role models and mentors, and information about careers (including those that do not require a college degree) are an integral part of the program. "Expanding Your Horizons" Conferences, based on the Math/Science Network model, will be offered in all seven SMART communities this year. But the key to the career component is to raise expectations of what girls can become. We don't accept self-fulfilling and limiting prophecies ("Our girls won't go to college") as justification for tracking girls away from the academic grounding they need for many jobs.

Our Experience in SMART by Age Group

We started by working with the 6- to 11-year-olds, the youngest age group served officially by Girls Clubs. (Many Clubs run pre-schools and day-care centers as well.) We drew on knowledge of early childhood throughout, however, since we knew that sex role stereotypes and gender expectations begin to develop in infancy and can become entrenched as early as the pre-school years. (Albert and Porter, 1983; Brooks-Gunn and Matthews, 1979; Entwisle and Baker, 1983; Lever, 1976; Nemerowicz, 1979; O'Keefe and Hyde, 1983; Pitcher and Schultz, 1983; Reid, 1982; Siegel, 1973; Whiting, 1983.) Also, pre-school approaches to science focused more on the kinds of experiences we wanted girls to have, experiences that involved their whole bodies and engaged all the senses, used lots of manipulatives, stayed away from pencil-and-paper except when necessary, focused on building and taking apart, and fostered imagination and creativity.

We had not anticipated that many of the 6- to 8-year-olds had never had the pre-school experiences, had never built with blocks, had never really grasped symbolic representation, and were now, in school, having great difficulty with such concepts as sequencing and number permanence. SMART Coordinators adapted their programs, using tangible objects--sticks, blocks, cutout animals--instead of numbers. They went for the unexpected. One Club did graphing, but not just on paper: ventilation grills and grids of any kind around one Club were transformed into matrices of coordinates.

We were quite successful in the first two years with the elementary school age group. Attendance was good (a key evaluation variable in a voluntary participation program), a core group of committed girls came back again and again, and girls stopped worrying about getting dirty, got beyond their "yuk" reactions, and felt freer to try new things.

A year ago we began programs for young adolescents, and faced a whole new set of problems. Attendance was inconsistent from day to day and week to week, so we designed activities that were not strictly cumulative. To sustain interest, the questions have to come from the girls themselves. This emphasis meshes well with a skill important in science: the ability to formulate a question worth pursuing and follow it through to resolution.

We also try to capitalize on the developing ethical awareness of early adolescents; model Clubs are designing community service projects that have a focus on science or technology. One Club is planning and building a challenge course in the park with the assistance of the Parks Department; another is working on cleaning up a polluted pond; a third is considering a social science project about the demographics of their Club community, a town in which the Puerto Rican minority is facing increasing discrimination in housing; an editorial in the local paper has proposed that no more Puerto Ricans be allowed to move into the town. The membership of the Girls Club is primarily Puerto Rican, and this project would afford girls an opportunity to apply scientific skills to a question that very directly affects their lives.

Counseling girls about course enrollment is another central effort of the early adolescent component. Clubs are collecting data about course offerings and enrollments in their communities, and designing presentations for parents, sessions with girls, and conferences with school personnel to raise awareness about the importance of making choices that keep options open.

Then of course, there is the issue of boys, and a reemergence, in a powerful way, of gender stereotypes and expectations (Hill and Lynch, 1983). In our coed Clubs, we have seen the phenomenon of girls who will no longer play basketball in the gym when the boys are there; they'll only watch. Or there is the example of Janie, who had been a confident leader among the SMART girls just months earlier, who feigns incompetence: sitting next to her boyfriend, she draws a rocket. Her boyfriend draws a rocket, copying Janie's but less skillfully. Janie crumples hers up and says "yours is great, mine's no good."

But we've seen progress too. Girls were fixing their bikes in the bike repair class being held outside one Club. A group of neighborhood boys walked by, saying "that's not girls' work." An 11-year-old girl retorted, "And who's going to fix my bike when it breaks? It is so girls' work!"

Documentation and evaluation are demonstrating that we are having an impact on the young adolescent age group. At one Club where teenage pregnancy is a major concern, "SMART is now the place to be," and staff are working to make this kind of engagement--in math, science, and technology--compelling enough to replace the anomie that too often leads to early pregnancy and involvement with drugs. Girls who thought a few short months

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age that the only jobs they could seek were "secretary," "nurse," and "teacher" are now lining up to become junior explainers at the museum, and thinking about careers they had never imagined, much less considered.

Planning for the high school age component is now underway, with programs for 15- to 18-year-olds scheduled to begin in 1988. Club activities will have a strong career focus, with internship and employment opportunities, scholarships to summer programs at universities, and tutoring and leading of courses for younger girls.

Preparing SMART Staff

One year into the project, we realized that training of staff is a critical need, for a number of reasons. First, the approach of scientific inquiry--of encouraging girls to question rather than giving them answers--does not come easily to most people. Background in math and science does not guarantee that someone will be able to present material in an open-ended fashion. Second, we want all staff to incorporate scientific inquiry into their program approaches, and that means overcoming the resistance that many women--and many Club staff--have toward math and science. Finally, in order for community-based organizations to offer science programs of top quality, Clubs need easy access to technical expertise, information, and resources.

MuseumLink is our answer. This pilot program with the Museum of Science in Boston brings adult Club staff to the museum for training in scientific inquiry and hands-on science, offers technical assistance, and provides answers to such queries as where to buy microscopes or find out more about Bernoulli's principle. More Club/Museum linkages are planned.

Collaboration is Key

Finally, we have found that collaborations--with schools, resource organizations, national and local agencies, professional associations of women in scientific and mathematical fields, other youth-serving agencies, and the media--go a long way toward making change happen. National linkages, of the kind that we have with the Association of Science-Technology Centers (in our MuseumLink project) and the American Association for the Advancement of Science (as one of the community-based organizations to whom they provide help in their Linkages project), have connected Operation SMART to resources and expertise that we could never have tapped alone. These national level connections increase the credibility of SMART at the local Club level; we also have a strong hunch that they will speed up the adoption of SMART by Clubs involved in the replication process.

SMART was not intended to be a substitute for basic education that girls should be receiving in school. But what became clear was that Clubs have the luxury to work with girls in small groups, to identify problems that might be missed in the classroom, and to offer a safe environment for children to admit to difficulties. We are still defining what our role in relation to the schools should be, and how we can act as advocates for improved, non-sexist math and science education.

Ultimately, the more that we can all work together, the more we can help increase the likelihood that girls will get a consistent message about math and science wherever they are, so that they take action and make decisions that allow them to take control of their learning, their lives, and their futures. That will make everyone's world a better place to be.

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RURAL WOMEN IN ORNAMENTAL AND MEDICINAL PLANTS

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Background

This village-based project was conceived in mid-1982 to enable rural women to contribute to the family income by tapping their unemployed time and skill for growing plants while they have to stay at home for their domestic duties as mother and/or housekeeper. In the Philippines, there are slightly more women than men, and rural women comprise 64% of the total female population.

The project endeavored and succeeded in mobilizing selected members of Rural Improvement Clubs[1] (RIC) to become producers and/or traders of ornamental and clinically-tested medicinal plants, and nursery plants of fruit trees in some places. It is expected not only to benefit their families, but also eventually contribute to the socio-economic development of rural communities.

Aside from the distinct advantage of the women not having to leave their household to become participants, the project involves a relatively simple technology, does not require a large capital outlay, makes efficient use of underemployed labor including other members of the household, enhances the primary health care of the family at reduced cost, and makes the home surroundings neat and beautiful.

It was planned to implement the project in selected countries in Southeast Asia as part of a program on "Women in Development", with the same design and allowable variations as long as it falls under Food and Agriculture Technology.

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[1] An association with all women members all over the Philippines and counseled by the Home Economics extension personnel of the Ministry of Agriculture and Food.

The Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) in collaboration with the Ministry of Agriculture and Food (MAF) started the project in the Philippines in August 1982. The Home Economics Division of the MAF Bureau of Agricultural Extension (BAEx) served as the lead national agency as well as the source of the core fund. The MAF regional offices served as the executing agencies. SEARCA provided the services of a Project Manager[2] who coordinated, directed and monitored the project's activities, assisted by a Project Leader from the MAF.

Objectives

The general objectives of the project are:

1. To improve the level of income of rural women and their families through the ornamental and medicinal plants enterprise; and

2. To enhance the roles of ornamental horticulture and indigenous medicinal plants in national development through their rural women.

The specific objectives are:

1. To establish a network of trained women producers of ornamental and medicinal plants in strategic sites;

2. To mount a production program for those types of ornamentals and medicinal plants with high market demand and economic potential at the village level through cooperatives;

3. To develop a marketing system through cooperatives which will lucratively absorb the outputs of the production program; and

4. To encourage the utilization of local medicinal plants by disseminating relevant information and by making them available, especially in the rural areas.

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[2] Author of this case report.

Implementation

The project has three components: research, training, and development (production and marketing with extension support).

1. Research

At the start of the project, a study on the STATE OF THE ART OF ORNAMENTAL HORTICULTURE IN THE PHILIPPINES was undertaken to determine the updated status of the enterprise by identifying research gaps and priorities, status of production and trade of ornamentals, and to be able to formulate recommendations to policy makers on how to promote the industry.

In this study, two major groups in the ornamental trade were considered, (a) cut flowers and cut foliage, and (b) potted plants, cuttings, and seeds. Both were found lucrative in the domestic market only; exports are insignificant and individualized. Examples of group (a) are roses, orchids, anthuriums, gladiolus, ferns; for group (b), crotons, *Ixora*, other landscaping plants including palms, *Aglaonema* and other house plants. The domestic commercial trade of foliage ornamentals started in the 1960's, has grown spectacularly, but unfortunately not professionalized nor organized. Their is awareness of the export potentials of Philippine ornamentals to Hongkong, Japan, Mid-East, etc. but quantity or volume requirements and quality control of exportable ornamentals are far from achieved. Furthermore, cooperatives development, while often mentioned as one key to the success of export marketing, has so far met stumbling blocks.

The State of the Art study presented data on costs and returns in ornamental production, cited problems in the industry, gave a listing of agencies, associations/clubs, and individuals involved in the ornamental enterprise. Resumé of researches on ornamentals, categorized by commodity, comprise a useful part of the report.

Production and marketing studies were also made in strategic locations representing potential agribusiness centers for the ornamental industry. Since resident researchers were tapped for these studies, aside from minimal support funding, local awareness and interest in the industry were kindled.

A BENCHMARK SOCIO-ECONOMIC SURVEY OF THE RURAL WOMEN PARTICIPANTS was initially conducted in the original sites of the project. A similar study was done in the first six sites after at least thirty months from the training. A comparative analysis of the two studies would be a basis for the first project evaluation.

2. Training

The implementing strategy adopted was to train trainors and/or coordinators, Senior Home Management Technicians (SHMT) and Home Economics Extension Specialists (HEES) of the MAF, who in turn, would organize in their areas of operation similar programs for their Home Management Technicians (HMT) and selected rural women. Trained together with the HMTs were agriculturists who were designated Technical Officers, (TO) of Propagation Centers in the regions and provinces. In addition, TOs were expected to serve as resource persons in the village training and as advisers to the women producers.

Selections of rural women for training were made according to the following guidelines:

1. She should be, (a) a member of a low income family; (b) in good health; (c) able to devote a few hours per day to the project and (d) a lover of plants (an indicator is the presence of some ornamentals around the house, even how lowly).
2. The household should, (a) be accessible to a reliable water supply; and (b) have available space around for

growing ornamentals.

The initial training was on PRODUCTION AND MARKETING OF ORNAMENTALS. Technology was not just spoonfed to the rural women; e.g., the science of botany was simplified by explaining to the trainees the structure and functions of the plant and its parts before cultural management topics were taken up; practices on postharvest technology (extending the vase life of cut flowers) were explained scientifically, not just demonstrated and steps on what should be done listed on the board for them to follow. They had to understand the scientific basis of the technology.

The training thrust for 1984 was PRODUCTION AND UTILIZATION OF MEDICINAL PLANTS. Only clinically tested indigenous plants were taken up. This was deemed relevant and timely in the light of soaring prices of medicine due to the high cost of imported drugs.

In order to prepare the participants for group maintenance and future expansion of the enterprise, COOPERATIVES DEVELOPMENT became the thrust of the training and action plan for 1985 to 1987.

As of the end of 1985, this program had directly trained a total of 1,464 rural women and 474 MAF technical and extension personnel in 48 provinces of 12 regions throughout the Philippines. Because of the multiplier effect of "echo training" in the villages, partial reports as of July 1986 revealed a total of 5,320 rural women comprising the network of producers of ornamental and medicinal plants in the project.

Training of new participants continues in the villages. There is a request for an advanced training of trainers for the regional coordinators on specific commodities, like orchid and anthurium culture, Bonsai, Fruit Nursery Management, etc. to be held in May 1987.

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Training is important but it is the action that follows which is the real indicator of success in project implementation.

3. Development - Production and Marketing with Extension Support

The action plans prepared by participants at the end of each training program included intensive production of ornamental and medicinal plants in backyards and community gardens, establishment of market outlets, holding of garden shows and trade fairs, and formation of cooperatives. Immediately after each training, the participants applied what they learned; here, the leadership of the HMTs (village coordinator) plays a crucial role. The resourcefulness and dynamism of the SHMT (Regional Coordinator), in no small measure, are equally important to the success of the performance of the project participants. However, the ultimate responsibility of performance rests on the participants themselves; thus recruitment of appropriate participants cannot be over-emphasized in project implementation.

Problems in Production. Three major problems have been identified. Firstly, there is the problem of lack of cheap sources of planting materials, of good quality and in big quantities. Mass clonal propagation for exportable ornamentals may have to be resorted to. Another option is to go into contract growing of selected crops such as palms, orchids, bromeliads. The second problem, which is the financial constraint for those who are dealing on more expensive plants maybe solved by contract growing schemes. Our country's rural banks do not extend loans for ornamentals. Organizing into cooperatives would be one solution. Another solution is for rural women groups to link themselves with an anchor corporation which can assist by way of funding support and at the same time, acts as the marketing arm.

Thirdly, there is inadequate professional technical assistance for the enterprise which is twofold: (1) lack of appropriate research-based technology especially for foliage ornamentals, (2) lack of professionally knowledgeable staff in the regional offices of MAF to assist the enterprise.

Benefits Derived from the Project

Aside from the income generated by producing ornamental and medicinal plants, other benefits derived were: (1) the unemployed time of the family are utilized; (2) the home surroundings become orderly, and beautiful; and (3) the women feel healthier and happier when they are engaged in gardening.

By growing and using indigenous medicinal plants grown and processed by them, medical expenses for such common ailments as cough, diarrhea, burns, fever, swollen gums, arthritis, tootache, headache, skin infections, and worms, have been reduced.

The question may be asked: If the women are happy, how about the men in the household?

The answer is: The men are also happy, because their wives are engaged in the "purest of all pleasures, which is gardening" - and they have not only become better individuals, but also better wives.

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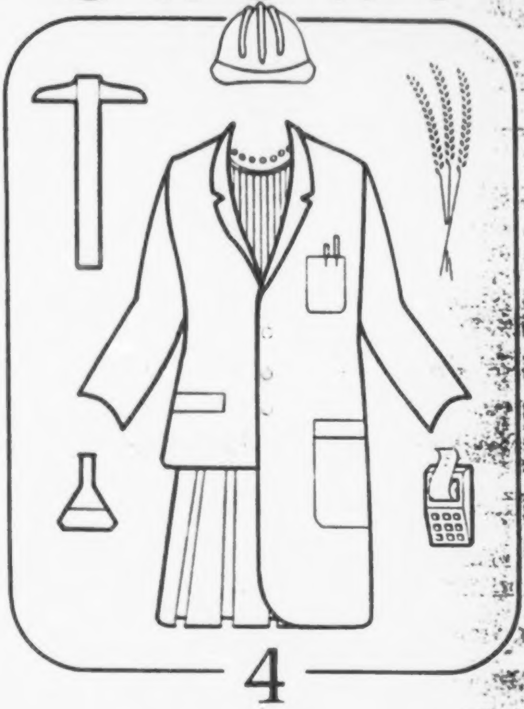
GIRLS AND SCIENCE AND TECHNOLOGY

GASAT



VOLUME TWO

CONTRIBUTIONS TO THE FOURTH GASAT CONFERENCE

July 24-29, 1987
The University of Michigan, Ann Arbor, Michigan U.S.A.

Edited by Jane Z. Daniels Jane B. Kahl

CONTRIBUTIONS TO THE FOURTH GASAT CONFERENCE
VOLUME TWO

University of Michigan
Ann Arbor, Michigan, U.S.A
July 24-29, 1987

Editors

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Publication sponsored by The National Science Foundation

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PREFACE

This book is Volume 2 of a three volume set of papers edited for the fourth international conference of Girls and Science and Technology-GASAT 4. The conference follows those held in Eindhoven, The Nethelerlands - 1981; Oslo, Norway - 1983; and London, England - 1985.

GASAT 4 will be held in Ann Arbor, Michigan at the University of Michigan on July 24-29, 1987. The submitted papers and conference proceedings will increase international knowledge and understanding of the value and diversity of the contributions of girls and women to science and technology and of the issues that affect such contributions. Special outcomes will include a better understanding of:

-barriers to women's education and participation in scientific and technological fields.

-strategies and interventions that can and do help to change or surmount those barriers.

-resources of people and materials, available around the world to assist and reinforce the work of Conference participants and their colleagues at home.

Participants in the GASAT 4 Conference represent 30 different countries. The pape-, written by these participants have been organized under the following headings:

-RESEARCH: Experimental
Qualitative
Empirical, Quantitative

-EVALUATION: Evaluation of Existing Situation and Recommendations
Evaluation of Specific Programs
Description/Case Studies
Theories and History

-INTERVENTION PROGRAMS

The papers within each areas are organized alphabetically by the first author's name. The three volumes of papers will be mailed to all particpants prior to the conference. Disscussion sessions will be held at the conference, focusing on each of the areas listed above. Following the conference, a book of conference proceedings and a congress book will be sent to everyone in attendance.

We hope that the research and experiences summarized in these three volumes expand your horizons and stimulate your thinking.

Jane Zimmer Daniels

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A LONGITUDINAL STUDY ON THE UNPOPULARITY OF PHYSICS AMONG GIRLS
QUANTITATIVE PART

Ton Jörg, Theo Wubbels, Magda Man in 't Veld[1]

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ABSTRACT

We describe the design of a longitudinal study that is currently being undertaken to discover why in the Netherlands so few girls choose physics as an examination subject in general secondary education. We follow students throughout a two year period of compulsory physics education. At the end of this course they are required to choose whether or not they will continue with physics. We collect our data on four occasions over a period of two years by means of questionnaires and interviews with students. At present we are able to give only the results of the first data collection. These show that even after two months of physics lessons differences have developed in some of the variables determining boys' and girls' responses to physics and in the numbers of boys and girls expressing an intention to continue with or drop physics.

INTRODUCTION

In the Netherlands far more boys than girls choose physics as an examination subject in general secondary education; at present the ratio is about four to one. In fact only 15% of the girls choose physics as an examination subject. Many people consider the unpopularity of physics among girls to be a major problem because dropping physics early reduces girls' possibilities for further education and employment. In our research project, which started in January '86, we are trying to find out why physics is so unpopular with girls. The project is based on the previous work that the first author carried out in the SISS-project (Second International Science Study) in the Netherlands. This research shows that after two years of compulsory physics education at secondary level girls' and boys' interest in physics and their appreciation of physics lessons differ substantially. This result had led us to investigate whether these differences existso throughout the two years of compulsory physics education or whether they develop gradually. The results of the GIST-project in England (Kelly & Smail, 1984; Smail & Kelly, 1984) indicate that when boys and girls attend physics lessons for the first time at the age of 13 their attitudes towards physics are pretty much the same. On the assumption that the situation is similar in the Netherlands we conclude that the unpopularity of physics among girls must be due to the nature and contents of the physics lessons themselves.

OPTION CHOICE FOR PHYSICS

In previous research it was found that interest in physics and appreciation of lessons were strongly related to choosing (or not choosing) physics as an examination course. It is well known that girls' interest in physics at the age of 15 is relatively low and that girls perceive physics as difficult. The contents and the nature of physics do not appeal to girls. The decision to opt for physics may also be linked with the student's personal characteristics and his or her career plans (Kelly and Smail, 1984) and with person or object orientation (Collings and Smithers, 1981). Students can be influenced by advice given by teachers or their choice may be determined by the social and economic status of their parents (Smail and Kelly, 1984). Finally teacher behaviour, the curriculum materials themselves and the way these are used may exert an influence on a students' decision to continue with physics.

In our project we selected a number of variables considered to be related to the option choice (intentional or definitive). We then incorporated these in a motivational model depicting a cyclical relation between variables (see fig. 1).

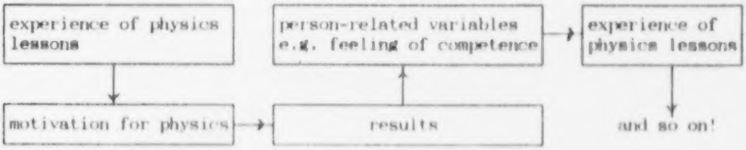
experience of physics lessons
person-related variables e.g. feeling of competence
experience of physics lessons
motivation for physics
results
and so on!

Figure 1: Cyclical model of variables relating to the option choice.

In this model motivation for physics is the main variable. On the one hand it influences person-related and (physics) education-related variables via (test) performance results and on the other hand it is itself influenced by these variables. In other words there is a cyclical relation between variables (cf. Burns 1982). This can be illustrated as follows:

A particular student's motivation for physics can diminish as a consequence of negative experiences in physics lessons. This reduced motivation can in turn influence the student's results, which subsequently can have a negative influence on person-related variables like feelings of competence. This will influence the students's feelings and opinion about the physics lessons, whereupon the cycle is complete and immediately recommences. In the top left box we put 'experience' of physics lessons. We have decided to use the term experience to the note 'feelings about' and 'responses to' lessons. It is said that compared with boys girls attribute failure more often to lack of ability, and success more often to good luck. Boys in general are more inclined to attribute success to ability (Nicholls, 1975). These patterns of causal attributions may lead in girls to a negatively self-reinforcing process. This can result in girls getting lower and lower marks, making it less and less likely that they will opt for physics.

Previous evaluation research in the PLON-project[1] produced some evidence that girls' experiences of physics lessons and their appreciation of physics are influenced by the curriculum materials the teacher uses (Wierstra et al., 1984). In the Netherlands the PLON curriculum is particularly interesting in this respect. This new curriculum incorporates many innovative features which were found to correspond to suggestions that have appeared in a number of published papers about making science more attractive to girls (Mottier, 1984; Lie and Bryhni, 1983). We shall therefore investigate the causes of the unpopularity of physics among girls with respect to two very different curricula: the PLON-curriculum and a starkly contrasting traditional physics curriculum. To summarize: in our project we shall investigate the influence that the curriculum (including curriculum materials) and person-related variables have on boys' and girls' experiences and on the appreciation of physics lessons and the influence that these variables exert on the choice of physics as an examination subject. In this paper we present results for the first phase of the project in which we were concerned chiefly with researching the following factors: do boys and girls differ - after two months - with regard to their motivation for physics, their experiences in and appreciation of physics lessons, person-related variables and their intention to choose physics after two months? We shall not pay attention to the differences between the curricula because we did not expect them to have an effect on students' responses so early on in the first year of physics education.

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METHOD

The question formulated above is being investigated in a longitudinal study which has both a quantitative and a qualitative part (see paper[3] by Man in 't Veld et al. in this book). In the quantitative part a questionnaire is administered to students (aged 13-14) four times over a period of two years, twice in the first year and twice in the second year, on both occasions after the first two months and at the end of the year. The questionnaire comprises various items concerning how physics is experienced, the learning environment, the difficulty and structure of lessons, the appreciation of lessons, motivation for physics[4], performance results, opinions about differences between boys and girls, future plans[4], person orientation and object orientation, feeling of competence[4] and intention to choose physics as an examination subject.

In October 1986 we collected data in 122 grade 8 (approx. age 13) classes. Physics teachers themselves helped to gather the data. Included in the sample are 22 schools (42 classes) in which the experimental PLON-curriculum is used. The rest of the sample was drawn from various types of Dutch secondary schools that use using the traditional curriculum materials. The response was very good (more than 70%) with 80 classes participating.

RESULTS

Most of the scales that we incorporated in the questionnaire are listed in table 1. Factor analysis on the data confirmed the stability of the scales we used in our previous research. On looking at the reliabilities of the new scales we conclude that they are useful for measurement. All the scales have a reliability greater than .50, which is sufficient for them to be used for comparing groups of pupils (Nunnally, 1967). In table 1 standardized differences are presented, both between boys' and girls' scores and between the scores of potential 'choosers' (those who express the intention to choose physics as an examination subject) and 'non-choosers' within each sex group. The size of the differences can be expressed (see Cohen, 1977) in terms of effect sizes: small, medium or large (for effect sizes of 0.2, 0.5 and 0.8 respectively). The figures show that for some variables there are very large differences between boys and girls, and for some variables the differences between choosers and non-choosers are even larger. This shows that the scales we use in our research are sensitive to differences between boys and girls and especially to differences between choosers and non-choosers. A plus sign shows that the mean score of the girls or of the choosers is higher than that of the boys or of the non-choosers. All of the relevant effects are in agreement with our expectations. The figures for "motivation for physics", the key variable in our research, show only a small difference between boys and girls, but they show a large and significant difference between the choosers and the non-choosers for both sexes. This variable measures how much attention students pay to the lessons and how much effort they put into their physics homework. We find quite a different picture for the variable "interest in physics"; the figures show a dramatic difference in the interest of boys and girls in physics after two months of physics.

	SCALES	NUMBER OF ITEMS	RELIABILITY (COEFF. ALPHA)	STANDARDIZED DIFFERENCE BETWEEN: BOYS' AND GIRLS' SCORES	CHOOSERS' AND NON-CHOOSERS' SCORES: BOYS	CHOOSERS' AND NON-CHOOSERS' SCORES: GIRLS
	ENGAGEMENT IN PHYSICS[i]	9	.83	-.13	+.68 s[*]	+.52 s
	INTEREST IN PHYSICS	7	.83	-.71 s	+.91 s	+.94 s
EXPERIENCE OF PHYSICS LESSONS	APPRECIATION	6	.88	-.39 s	+.82 s	+.77 s
	STRUCTURE	5	.68	-.25 s	+.68 s	+.60 s
	INSTRUCTIVENESS	6	.79	-.36 s	+.63 s	+.60 s
	DIFFICULTY	5	.76	+.49 s	-.53 s	-.49 s
EXPERIENCE OF LEARNING ENVIRONMENT COMPONENTS	PARTICIPATION LEARNING	6	.68	-.12	+.24 s	+.34 s
	ENQUIRY LEARNING	7	.72	.00	+.11	+.22 s
	REALITY LEARNING	5	.64	-.12	+.23 s	+.24 s
PERSON-RELATED VARIABLES	RELEVANCE OF PHYSICS FOR STUDENTS' FUTURE[i]	4	.86	-.37 s	+.86 s	+.93 s
	PERSON ORIENTATION[i]	3	.58	+.62 s	-.12	.00
	OBJECT ORIENTATION[i]	3	.59	-1.00 s	+.30 s	+.34 s
	OPINION ABOUT EQUALITY OF SEXES REGARDING PHYSICS[i]	7	.64	.00	-.26 s	+.56 s
	INSECURITY[i]	4	.56	+.13 s	-.28 s	-.26 s
	FEELING OF COMPETENCE[i]	5	.69	-.37 s	+.68 s	+.65 s

[*] An s means that the difference is significant at the 0,1% level.

[i] These are the new variables (scales), introduced in this research.

Table 1: Overview of scales, their reliability and the standardized difference between the sexes and between the choosers and non-choosers within each sexgroup.

The scales measuring aspects of the learning environment show no differences for boys and girls; this means that boys' and girls' perception of the actual learning environment is very similar. We find significant but small effects regarding the difference between choosers and non-choosers, the latter perceiving the aspects of the learning environment less favourably than the choosers.

The picture provided by the scores on the person-related variables is rather complex. Physics already seems to have different relevances for boys and girls. The variables "person orientation" and "object orientation" show rather dramatic differences between boys and girls, i.e. the effect sizes are larger than ;50 (medium effect size). The last three person-related variables in table 1 give exactly the opposite picture: there are no differences or only minor differences (feeling of competence) between boys and girls. Finally it is worth mentioning that 75% of the boys said they intended to choose physics as an examination subject whereas only 45% of the girls said they intended to do so. This differs from the situation at the end of two years of compulsory physics education when more than 50% of the boys and only 15% of the girls choose physics definitively as an examination subject. Although the difference between the 75% and the 45% is rather large, it shows that a lot of girls do think positively about physics, at least early on in the course.

CONCLUDING REMARKS

The differences between boys and giris for most of the variables are rather dramatic. Important for our research is the finding that although girls are much less interested in physics after two months, they are still just as motivated for physics as the boys are (cf. van Aalst et al., 1985). We expect that especial for girls this motivation will decline in the course of two years of physics lessons and taht this decline will have effects on performance (achievements) in physics and on the person-related variables. In the two years remaining for our research project we shall try to find out whether the model we have devised to explain this process is a good one. The interviews we have with the girls, four times in two years, should also help us to obtain more insight into this process.

1) We should like to thank Erik Ellinger, Yvonne Sweers and Sheila McNab for their various contributions to this paper.

2) PLON is the Dutch acronym for Physics Curriculum Development Project (1972-1985).

3) Magda Man in 't Veld et al.: A longitudinal study on the unpopularity of physics among girls. Qualitative part. In this book.

4) The items for these variables were taken over from Derriks and Mechteld (1983)

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8

Out-of-School Science : Are Gender Differences Related to Subsequent Attitudes and Achievement in Science?

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Summary

This paper reports Australian data on the out-of-school science-related activities of 13-year-old students. The data provide information parallel to that available from surveys of the Assessment Performance Unit and national Assessment of Educational Progress in the United Kingdom and the United States, respectively.

The research describes the out-of-school experiences of girls and boys as they enter their first high school year, and examines the relationships between these experiences and students' science-related attitudes and achievement in science at school. The results show that boys and girls have patterns of experiences which are similar to those found elsewhere. Such experiences are related to students attitudes to science at school, but in these data, are not related to differences in achievement.

Large scale surveys such as the IEA (Kelly, 1978), NAEP (Hueftle et al, 1983; Kahle & Lakes, 1983) and APU (Johnson & Murphy, 1986) consistently find that boys participate more than girls in out-of-school science-related activities, particularly in activities which are associated with physical science. The case has been well argued that students' science-related experiences influence their science-related attitudes (Kahle & Lakes, 1983) and their achievement (Johnson & Murphy, 1986). However, meta-analyses of empirical research typically find that correlations between attitudes and achievement in science are generally low (Steinkamp & Maehr, 1983; Willson, 1983). Further, the persistent gender differences in patterns of out-of-school science-related activities are matched in neither magnitude nor consistency by gender differences in attitudes and achievement at school. These findings suggest that the belief that out-of-school science-related activities are an important influence on science-related affect and achievement in science at school requires careful examination, and that is the purpose of this paper.

The research reported here describes the out-of-school science-related experiences of girls and boys as they enter their first high school year and examines the relationship between these experiences and students' science-related attitudes and achievement in science at school. By using a repeated measures design, the pattern of relationships between the same variables can be examined near the beginning and near the end of the academic year. The results provide answers to three questions: Do these boys and girls have different out-of-school science-related experiences? Are the experiences of boys and girls related to differences in attitudes and achievement in science at school? Can differences in science achievement be attributed to differences in out-of-school science related experiences?

Method

The influence of out-of-school activities on attitudes and achievement is likely to be greatest as students enter high school, where general science becomes compulsory for all students. Most students have little experience of science in primary school, perhaps one hour each week. In contrast, science is taught for four hours a week in high school, by specialized teachers in specialized rooms, and is formally assessed. Affect towards science is likely to change and develop during this year and in order to reflect its natural development, the study was carried out in the context of normal school routine, using intact classes with their usual science teachers.

The sample of 390 13-year-old students included all of the first year students attending two government, coeducational high schools in Perth, Western Australia. The schools served areas of middle-class socioeconomic status and classes were unstreamed and heterogeneous in ability. In one school, students used activity-based science curriculum materials in a self-paced way. In the other school, they used similar materials, but usually worked in small groups under the guidance of the teacher.

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Data were collected during March and October (near the beginning and end of the academic year). Complete sets of data were obtained from 172 boys and 170 girls, which is 88.6% of students from the original sample. About half of the loss was due to absence or transfer from school, and the remainder due to incomplete data.

Measurement of Variables

Out-of-school science-related activities were measured with an instrument named ACTIVITY containing items described as "Things I have done because I was interested and wanted to do them". The four point frequency response format asked students to select from "I have done this thing never - once or twice - a few times - often". A pool of items was prepared in consultation with thirteen science educators and a small group of 13-year-old children. Items related either to a specific science topic (such as making a rock collection) or relating to a general science activity (such as read a science fiction book). Both active and passive verbs were used to describe the activities.

The items were trialled in a pilot study using 315 13-year-old students from five schools including government and private schools representing a range of socio-economic status. No problems were encountered by students in responding to the items, although several items were deleted because of very low means. The twenty items retained were matched to form two parallel scales, each of twelve items with four items in common. Item wording and statistics for the two forms of the scale are reported in Table 1.

Science-related affect is conceptualised in this study as a global variable with four components: enjoyment of science at school, perception of past performance in science, expected future performance in science, and the perceived usefulness to students of science at school. Each of these four components is measured by a Likert-type scale in which items have four response choices: strongly disagree - disagree - agree - strongly agree.

The development and validation of these scales is described in detail elsewhere (Rennie, in press). Enjoyment in science is measured by two parallel ten-item scales named ENJOY. A typical item is "I look forward to science lessons". Students' perceptions of their past performance in science at school is measured by an eight-item scale named PAST; a typical item is "I feel I've learned a lot in science so far". Expectations of future performance in science are measured by a nine-item scale called FUTURE. A typical item reads "I expect to do well in the next science test". The perceived usefulness of science was measured by a ten-item scale named USEFUL, containing items such as "The things we are doing in this science topic are useful to me". These last three components are measured by scales containing items referring to the specific science context in which they are administered, so parallel forms were not needed for the two occasions of measurement. The reliabilities for all scales are reported in Table 2.

The affective data were collected during the second and eighth of the nine science topics which students studied during the year. Achievement is measured by the school-developed topic test for the second and eighth topics, that is, the measurement of achievement occurred at the ends of the topics during which affect was measured. Most of the topic tests consist of multiple-choice items which allows for some uniformity of marking between classes. However, since different selections of general science topics were studied in the schools, achievement scores are not comparable between schools.

Results

The first analysis concerned the ACTIVITY scales. There were no between-school differences on any items, so data for each sex were pooled over schools, and the results appear in Table 1. Boys are more likely than girls to have engaged in activities related to physical science, and activities involving "tinkering". Further, these differences persist

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Table 1
Mean Scores of Boys and Girls for Out-of-School Science-Related Activities

Activities Related To Science	March			October		
	boys	girls	t	boys	girls	t
1 Looked through the science books in the library	.90	.85	.49			
2 Built working models of mechanical things	1.30	.41	8.99**			
3 Watched, or listened to science programmes on the TV or radio	1.35	1.23	1.17			
4 Read a science fiction book	1.84	1.55	2.46*			
5 Spent my own money on things to do with science	.73	.39	4.00**			
6 Built or repaired radios or other electronic gadgets	1.59	.54	9.78**			
7 Thought about problems like how the earth, sun and stars were made	1.92	1.62	2.72**			
8 Thought about questions like what are atoms? How do living things work?	1.60	1.26	3.02**			
9 Wondered what light is, and how it is used in optical instruments like binoculars and microscopes	1.45	1.12	2.93**	1.43	1.01	3.85**
10 Kept animals, like caterpillars or tadpoles to see how they live	1.69	1.63	.54	1.62	1.72	-.96
11 Made my own rock collection	.84	1.01	-1.49	.99	.96	.31
12 Tried to find out more about how plants grow	1.08	1.21	-1.26	1.03	1.14	-1.07
13 Asked adults questions about science because I am interested				1.35	1.18	1.58
14 Tried to find out about the history of scientific discoveries				.82	.54	2.87**
15 Read science magazines like National Geographic, New Scientist or Scientific American				.84	.54	3.02**
16 Tried to find out more about electricity and electronics				1.56	.51	10.45**
17 Read newspaper articles about scientific things				1.39	1.25	1.24
18 Wondered how substances like soap and plastics are made				1.29	1.32	-.25
19 Played with chemicals and chemistry sets				1.74	.95	6.86**
20 Talked about scientific things with my friends or other students away from school				1.10	.71	3.82**

* $p < .05$ **$p < .01$

Table 2
Reliability Coefficients[a] and Correlations[b] Between Affect, Achievement and Out-of-School Science-Related Activities

	March						October					
	1	2	3	4	5	6	1	2	3	4	5	6
1 ACTIVITY	.81	.54	.29	.37	.56	.12	.86	.52	.32	.44	.47	.18
2 ENJOY	.48	.88	.50	.63	.64	.11	.51	.90	.50	.66	.69	.23
3 PAST	.34	.56	.81	.74	.33	.47	.32	.51	.89	.82	.36	.55
4 FUTURE	.41	.67	.73	.82	.51	.28	.44	.59	.75	.87	.51	.42
5 USEFUL	.39	.64	.36	.49	.85	-.02	.55	.62	.31	.47	.87	.15
6 TEST	.13	.28	.39	.37	.14	na	.19	.21	.45	.40	.17	na

[a] Alpha reliability coefficients form the diagonal of the matrix and are underlined for ease of reading.

[b] Correlations for girls are reported above the diagonal. Correlations for boys are reported below the diagonal. For $r > .21$, $p < .01$; $r > .16$, $p < .05$.

through the first year of high school. These gender differences are very similar to those reported in NAEP and APU studies (Johnson & Murphy, 1986) and show that the science-related activities of Western Australian boys and girls match those of students in the USA and United Kingdom. Since the differences all favour boys, scores for the items of each scale were summed to a total for the ACTIVITY scale.

To account for differences between schools and systematic between-class differences in attitudes and achievement which may be related to the teacher, to some factor of class history, or to the particular science topic studied at the time of measurement, an error correlation matrix for each sex accounting for both within-class and within-school variance was calculated and these error matrices were used for all subsequent analyses. The error correlation matrices are reported in Table 2.

The patterns of correlations are similar for boys and girls, and similar between occasions. Participation in out-of-school science-related activities is positively correlated with the affective variables. Correlations are about .50 with enjoyment and perceived usefulness of science, but less with perceptions of past and future performance. Correlations are low, less than .20, between out-of-school activities and achievement. Multiple linear regression analyses were performed to determine the variance in common between out-of-school activities and the four affective variables. The squared multiple correlation coefficients are $R^2=.37$ for girls and $R^2=.25$ for boys in the March data. The corresponding values for the October data are $R^2=.31$ for girls and $R^2=.36$ for boys. Regression analysis indicated that the affective variables accounted for significant proportions of the variance in achievement, between 18% and 31% in these data. However, the inclusion of out-of-school activities as an additional predictor variable accounted for no more than a nonsignificant 1% of common variance.

Discussion

The out-of-school science-related activities of these Australian students are similar to those elsewhere - boys enter high school with more science-related experiences than do girls, particularly in the physical sciences. The out-of-school experiences are related to students' science-related affect, with between one-fourth and one-third of shared variance. Most of the common variance is accounted for by students' enjoyment and their perceptions of the usefulness of science. In contrast, very little variation in achievement can be attributed to out-of-school science-related activities, with correlations less than 0.20 in each data set.

These results demonstrate that greater experience by boys in science-related activities does not necessarily lead to higher achievement. The relative inexperience of girls and associated lack of familiarity with science equipment seems to have been overcome in the activity-oriented style of science-teaching that the students experienced in the schools involved in this research. However, other research (see, for example, Kelly, 1985) suggests that same outcome may not occur if there were to be competition for equipment, and/or girls did not have many opportunities for practice to catch up on their lack of skills. What is suggested by the present results is that while early science experience may favour boys, in an appropriately structured learning environment girls need not be left behind in terms of their science achievement.

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16

GIRLS' CO-OPERATION AND BOYS' ISOLATION IN ACHIEVING UNDERSTANDING IN CHEMISTRY

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Introduction

There has been much recent concern about the motivation of women students to study science and mathematics, an issue of central concern to the GASAT conferences. In New Zealand, as in many other countries, while biology is a popular choice for female secondary students, other sciences such as chemistry and physics are more likely to be taken by males than females, a trend which is exaggerated even further with indigenous Maori students. This paper considers the process of students' learning in chemistry and appropriateness of current teaching practices for women students.

Current developments in the field of "achievement motivation" are relevant for understanding differences in the way girls and boys approach science activities. One recent theoretical approach proposes that education systems tend to produce a type of motivation called "ego involvement" (Nicholls, 1983). In this view, the student is motivated by a concern with how much ability or intelligence she or he has. The ego-involved orientation involves a belief that "intelligence" or abilities such as "mathematics ability" are stable or fixed in each person. The ego-involved orientation also assumes a negative correlation between intelligence and effort expended to complete a task (i.e., that "smart" people do not need to try as hard as less smart people to do well on a task).

However, because of developmental changes, ego-involved beliefs would not have full impact until adolescence. As the child develops and becomes more aware of other people's perspectives, there is greater concern with "presentation" of oneself to others. The result would be a tendency to avoid a show of effort in class, since to try hard and NOT do well would lead others to infer that one is dumb. The ego-involved student in a science classroom would be someone constantly worried about not looking dumb, since, with each year in school the content encountered is increasingly difficult, with one's competence again open to challenge. In this situation only the most confident students would believe that their intelligence would carry them through to future success. Given that boys seem to have higher expectations about their performance in a variety of academic situations (see Bird, 1984; Lenney, 1977; Parsons and Ruble, 1977), it is plausible to think that the most confident students are more likely to be the boys who have been geared towards science-related activities from a young age.

A contrasting motivational orientation in Nicholl's theory is that of "task involvement", in which students are engrossed in the task on which they are working, and on improving their knowledge and skills as much as possible. Task-involved students would not believe that abilities are stable and fixed, but would be motivated to improve various skills and increase their intelligence, which is not seen as fixed. These students would not be concerned about publicly revealing the amount of effort put into a task, because they focus their attention on the task itself and not on their views of what others think of their efforts.

Educational sociologists Rosenholtz and Simpson (1984) have argued that the increasing formality of classrooms and marking practices as the child moves from primary to secondary schooling encourages children to develop fixed views of their abilities related to "ego involvement". They contrasted "unidimensional" classrooms, in which every child is involved simultaneously on the same tasks, to the "multidimensional" classroom, in which students engage in many different kinds of activities. Because children in multidimensional classrooms cannot so easily compare their performances with that of their classmates, it is more difficult for these children to rank each other on a unidimensional scale of "brightness" or competence. It seems plausible that the multidimensional classroom would be one in which task-involvement is more likely to flourish.

The relevance of gender for this motivational theory comes from observations about the change from the primary school classroom, in which there are integrated activities, a focus on effort and conduct, and an environment in which girls excel, and secondary school classrooms, with their focus on isolated academic subjects and evaluations based on external standards of achievement, in which boys are more likely to excel, especially in scientific and mathematical fields (see Eccles, 1986). It may be that girls, who have focussed on the importance of effort, neatness and being the "perfect student" in primary school are at a disadvantage when they reach adolescence and face the ego-involved consequences of putting great amounts of effort into their work. They would be more likely to be seen as "sloggers" (see Dweck and Elliott, 1983) who do not have a "natural" intelligence or "flair" for their academic work. This theory has great relevance for views of girls' motivation to continue with science in school. If girls are at greater risk of negative consequences in the ego-involved classroom, the extent to which science classrooms encourage ego-involvement, with their characteristic "unidimensional" practices, needs close examination.

It has been suggested by other educational theorists working in the field of motivation (Entwistle and Ramsden, 1983), that students motivated by their involvement with the learning activity itself, which may be described as task-involvement, adopt a "deep" approach to learning (Marton and Saljo, 1976) by focussing on meaning, actively interacting with the material and making links with "real life". Those students who are motivated, on the other hand, by evaluation concerns in their hope for success or fear of failure (more ego-involved concerns) would tend to adopt a "surface" approach with the goal of reproducing the information given. The present study examines a number of aspects of students' orientations towards their learning in chemistry, to see whether young women because of cultural expectations are less likely to be engaged with deeper meaning aspects of what they are learning.

Background

This study describes work which is part of an evaluation of senior secondary school chemistry in New Zealand. The evaluation was carried out in response to concern about declining proportions of students taking chemistry in Form 6 (16-year-olds in Year 12 of schooling), and about the poor performance of these students and of students taking chemistry in the following, final year of school. Although understanding is emphasised in the prescriptions for both of these courses, even the best students in the final year examination were able to do little other than recall information. The research began with an analysis of participation rates and examination performance of students in chemistry at secondary and tertiary levels, and focussed on Form 6 students and their reasons for selecting or rejecting the study of chemistry, their attitudes to chemistry (Burns, 1982) and finally their understanding in chemistry.

Although gender differences were not among the concerns which led to this study, differences found in participation rates in science and chemistry led to the inclusion of gender as a factor in the selection of students.

A survey by questionnaire of a nationally representative sample of Form 6 students in 1981 showed that girls were more likely than boys to choose chemistry because they needed it for their career, less likely to choose it for enjoyment or because they expected to be successful. Girls more often than boys rejected chemistry because they thought it would be too difficult. While girls and boys regarded chemistry similarly favourably, girls felt significantly less certain about it. In a follow-up survey of Form 6 chemistry students carried out later that year, it was found that although there was no significant difference in girls' and boys' overall achievement in the previous year's national School Certificate Examination (largely norm-referenced) girls perceived it to be significantly more difficult than boys to achieve understanding in Form 6 chemistry. Gender differences in the process of achieving understanding have implications for teaching and will be discussed in this paper.

Method

In 1983 a sample of Form 6 chemistry students (17 girls and 22 boys) from six chemistry classes in six schools in the Wellington area were interviewed about their understanding in chemistry. While resources did not permit the use of a national sample of students, the selection procedure ensured that as far as possible the students chosen reflected the diversity in the population. Four of the schools selected were coeducational, one was a girls' and the other a boys' school, and these schools included students of a range of ethnic origin. The chemistry classes were taken by two female and four male teachers who had each had at least three years experience teaching Form 6 chemistry. The sample design required selection of equal numbers of girls and boys from the top, middle and lower thirds of overall achievement level in School Certificate, determined nationally for Form 6 chemistry students; but because of the uneven distribution of girls and boys, and of students of the various achievement levels, among the sample schools, a smaller number of girls than boys was selected. Students were interviewed individually. A frame of reference was established prior to each interview by the students' response to a written question in which they rated their perception of understanding of various chemistry topics. The first part of the interview lasted about 25 minutes, was loosely structured and probed the student's understanding of understanding, her/his method of assessing understanding and process of achieving understanding. The second part of the interview investigated the student's understanding of various chemistry topics and will not be considered in this paper.

Results

Students' understanding of understanding and method of assessing understanding (Burns, 1987) are summarized here to provide a framework for discussion of the process used to achieve understanding. Students exhibited two orientations toward understanding in chemistry: one was concerned with the recognition of order within a topic, students felt they understood when they could appreciate relationships between concepts; the other was associated with the recall of facts and rules, students felt they understood when they knew "a fair amount" about a topic. Two orientations toward assessment were also evident. "Intrinsic assessment" was made by students who recognized understanding for themselves and "extrinsic assessment" by students who used feedback from tests or assignments. Prelimin , results suggest that, for understanding in chemistry, high achieving students and girls tended toward the recognition of order among concepts, and lower achieving students and boys toward the accumulation of knowledge. Of the students concerned with the recognition of order boys tended to assess understanding intrinsically and girls to employ extrinsic as well as intrinsic measures. Some lower achieving boys actively rejected extrinsic information which contradicted their perception of high understanding by saying, for example, "I'm not so good at tests".

Students described four different ways of achieving understanding, these were: working alone; asking the teacher; asking classmates; and seeking help from family and friends outside the class. Individual students used one or more of these methods with varying emphases.

Nearly all girls and boys worked on their own at some stage, using mainly their class-notes and textbook. It was a first course of action, however for 85% of boys, but only 60% of girls. One-third of the boys, but no girls, said they preferred to work on their own rather than consult others. High achieving students tended to use other reference books in addition to the school text and directed their work more specifically recognizing problems and looking up particular points. Lower achieving students found a variety of books confusing and contented themselves with "reading and re-reading" and "doing examples".

Sixtyfive percent of girls and 30% of boys asked the teacher for help, though some only did this in the privacy of, for example, a tutorial. A further 25% of boys said they would go to the teacher "as a last resort" or if they "really had to". While further small proportions of girls and boys said they really should ask the teacher because the teacher "knows best", many (40%) said they preferred not to ask the teacher - girls generally because they did not want to be a nuisance and boys because they did not want to look dumb. Some girls and boys said they would not ask the teacher.

More girls than boys, 80% compared with 50%, consulted other students in the class. Twenty percent of boys said they would not ask other students, but no girls said this. Girls enjoyed discussion with their friends and went out of their way to find time for this, for example, before school began. During class-time the only opportunity for discussion occurred during laboratory sessions. One of the main advantages of discussing work with classmates rather than the teacher was that communication was better. Teachers often talked above the students' heads and used technical language that students did not understand. Other students used "the same language" that they did and recognized their problems. Sixtyfive percent of girls found discussion with other students more helpful than discussion with the teacher for these reasons. Only 30% of boys mentioned this, but fewer boys discussed their work with other students.

Twentyfive percent of girls but only one boy asked people outside the class for help.

When asked about their goals in understanding most of the girls focussed on understanding "as much as possible", a third were doubtful of their ability to cope and a few aimed to "pass the exam". By contrast half of the boys gave goals related to examination success, including being "top" and getting high grades, and the others focussed on understanding, only two expressed doubts about their ability.

Discussion

Clear differences existed between Year 12 girls and boys in this study in their perception of understanding in chemistry and in their corresponding study strategies. Girls appeared more likely to focus on relationships among concepts in the material studied, which was a pattern also associated with high achievement. A focus on relationships between ideas is a characteristic of students with a "deep" approach to learning (see Entwistle and Ramsden, 1983) who are more likely to be motivated by involvement with the learning activity itself. Thus girls in this study appeared to be more task-involved in their approach to understanding.

More outstanding than the differences between girls and boys in their perception of understanding were those evident in the way in which they went about achieving understanding. Girls more than boys sought discussion with the teacher and with friends and family. They were less concerned than boys about competition with their peers or with impressing the teacher. This tendency for female students to ask for help from classmates and their teacher suggests a positive motivational orientation that is task-involved. One characteristic of task-involvement, but not of ego-involvement, is that the student has no hesitation about asking for help or discussing the task, because of the focus on learning rather than on embarrassment

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about revealing in public that one is ignorant (see Dweck and Elliott, 1983).

However, although girls exhibited more task-involvement in achieving understanding than boys, they appeared less sure of their ability to understand the subject. Of those students who perceived understanding in terms of relationships among concepts (task-involved), girls were more likely than boys to use external criteria as well as intrinsic measures to assess their understanding. Boys were more confident of their own assessment of their understanding and were less willing to accept conflicting evidence from test results which suggested a lack of understanding.

For these students who were both actively involved in coming to grips with understanding at a conceptual level, why is it that boys were more confident of their ability to assess their undersanding intrinsically than girls? By the time students reach Year 12 they have spent three years in the more ego-involved classrooms of secondary school (see Rosenholtz and Simpson, 1984), which are less likely to be comfortable learning environments for girls (see Eccles, 1986). They have also developed increasingly gender stereotyped views of science (Kahle and Lakes, 1983). For boys, there are probably stronger cultural expectations to be good at chemistry and therefore boys have more to lose in "looking dumb". There are no such expectations for girls, therefore it may be expected that girls would be less likely to be embarrassed about displaying their ignorance of chemistry in a co-operative process of achieving understanding. Even the highest achieving girl in this study (an average of 89% in her best four subjects in School Certificate) said "I built up a kind of thing in my mind that I could not do chemistry - I was terrible at it", and said that when she needed help she "asked some bright people in our class"!

It is interesting that there was a gender difference found in this study, while another Wellington study (Bird, 1986) with 9-year-old children found no gender difference in children's hesitancy about seeking help in the primary school classroom. If it is the female students who are maintaining more co-operative and task-involved attitudes in their work by the time they reach secondary school, then perhaps there is a good basis for building a more task-involved classroom using the strengths of the co-operative approach signalled by these young women. This might help to counteract some of the negative effects on girls of the change from primary to secondary school (see Eccles, 1986). These young women's ability to work co-operatively may signal some unusual strengths which could be better used to enhance their learning as well as their enthusiasm about chemistry.

Implications for teaching

This study indicates that current teaching practices do not meet the needs of female students in their search for understanding in chemistry, nor do they encourage a task-involved approach to understanding. The influence on teaching practices of course prescriptions and assessment procedures are considered and suggestions are made for changes.

1. Overfull, conceptually difficult prescriptions, common in chemistry and science courses in New Zealand and elsewhere (Ormerod, 1978) encourage science students to adopt a "surface" approach to learning (Entwistle and Ramsden, 1983). Prescriptions with less content would allow time for discussion between students, and between the teacher and student, and encourage learning oriented toward meaning. They would also meet the immediate needs of female students.
2. Norm-referenced assessment and internal assessment in New Zealand secondary schools encourages competition. Co-operation in learning is therefore covertly and in some cases overtly discouraged (Burns, 1987). Girls because of their preference for interaction in achieving understanding are seriously disadvantaged. Although the current increase in internal assessment should allow for more qualitative evaluation and therefore more "multidimensional" classrooms which encourage task-involvement, there is also the danger that with continued norm-referencing the teacher will be seen increasingly as a judge. This will further discourage the competitive boys from seeking help.
3. "Unidimensional" classrooms and a preoccupation with "getting through the prescription" (a consequence of overfull prescriptions) contributed to the high teacher control and competitive atmosphere typical of the environment of classrooms in this study (Burns, 1987). According to Fraser et al, (1983) these conditions in science classrooms increase student anxiety. An increase in student

participation and a co-operative atmosphere would decrease anxiety especially for girls who feel less certain. Moves in this direction could be made by the introduction of "multidimensional" classrooms and the reduction of prescription content. The result would be an environment more appropriate, not only for girls, but for task-involved learning.

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26

A LONGITUDINAL STUDY ON THE UNPOPULARITY OF PHYSICS AMONG GIRLS
qualitative part

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ABSTRACT

A longitudinal research project started in January 1986 to investigate the causes of the unpopularity of physics among girls during their first two years of physics education. This paper provides information about the design of the qualitative part and about the first interviews conducted with girls. We report on some data and some provisional results of analyses.

INTRODUCTION

A research project started in January 1986 to investigate the causes of the unpopularity of physics among girls at schools in the Netherlands providing General Secondary Education (see also Jörg et. al. in this book[2])). The qualitative part of this research project includes a series of in-depth interviews with girls. At eight of the schools participating in the research project we asked thirty-two female students to take part in a series of interviews. These interviews will take place at the beginning and the end of the first and second year of compulsory physics education at about the time when the questionnaires are administered.

METHOD

The eight schools selected for the interviews consists of four schools which have a traditional physics curriculum and four schools which have a innovative physics curriculum[3]). From these two types of schools we have chosen two schools which have a relatively large and two which have a relatively small number of girls opting for physics as an examination subject. At each school we asked for the participation of four girls who are likely to go up from form two to form three at the end of the year and whose achievement is average. We selected girls who had gone up from form one to form two having an adequate but not too high a mark for mathematics.

The interviews are semi-structured. For every interview we use a checklist of relevant topics, grouped around five starting questions. These five questions concern experiences in physics lessons, learning environment in physics lessons, attitudes to physics lessons, degree of satisfaction with evaluation outcomes and perceived importance of physics for the student's future life. First the interviewee can talk about whatever comes up to her mind. If necessary the interviewer asks additional questions on topics in the checklist. The results of the first data-analyses will determine whether we decide to collect supplementary data by classroom observations, by interviewing male students and/or by interviewing teachers.

The first analysis can of course lead only to provisional conclusions. The semi-structured feature of the interviews and the repeated contact with the interviewees gives us the opportunity to insert new questions which are generated by analysis of the previous data. We expect in the course of the project that the consecutive analyses will lead to a coherent and complete description of the individual girls.

CONTRIBUTION OF THE QUALITATIVE PART TO THE RESEARCH PROJECT

Data for the qualitative and the quantitative part of the project will be compared. The purpose of this comparison is twofold. First of all it will enable us to validate results of the quantitative part. We shall award scores to some of the interview protocols on the basis of data concerning the quantitatively measured variables and we shall compute correlations between these scores and the questionnaire scores. Secondly the quantitative data will provide information about the interviewed girls, which will enables us to compare the limited group of interviewed girls with the total population and to find out in what ways the results of the interview analyses correspond to the findings for the total group.

The outcomes of the quantitative measurements will give us information about the interdependence of variables. The interviews will provide us with insight into the processes that accompany the hypothesized reduction in girls' motivation for physics and into the mechanisms that cause interaction between students' experiences, their motivation, the teaching methods used and features of the physics curriculum.

Two theoretical models are of importance for analysing the interview data. First of all there is the cyclical motivational model on which our study is based. This model describes a psychological process; in this model motivation is the key variable (Jörg et.al. 1987^{a})). As we mentioned above our first purpose is to validate this model on the basis of data of both the qualitative and quantitative part of our research project. Secondly there is the model of Eccles (1986), which describes how socialization processes are linked to psychological factors. In the explanation of her model Eccles stresses that it is important to know more about women's own reasons for the achievement-related choices they do (Eccles 1986). We expect to find that many of the interview data are related to the linkage between socialization processes and psychological factors. We want to evaluate both models in relation to the interview data. For instance the question has to be answered if the achievement-related behaviour of girls of age 13 - 15 involves elements of choice and if the interview data reveal these elements of choice.

ANALYSIS

At this moment we are processing the data for the first series of interviews. In this paper we present data from four of these interviews. We have decided to use these particular interviews to develop a number of categories because of their rich content. The interviews with Mabel and Elsa took place at two different schools each of which has a traditionnal physics curriculum and the interviews with Cecil and José (who are class-mates) took place at one school which has the innovative curriculum. The interviews took place about eight weeks after the start of the two-year compulsory physics course, when the girls were about 13 years old.

We present some selected data concerning the personal circumstances, personal features and expectations of the interviewees. These kinds of data will enable us to compose a portrait of every girl. On the basis of these portraits we can interpret data on the classroom experience and the behaviour of each individual girl. In order to map the data we need to construct categories which 1) combine the information from different parts of the interviews adequately so that we can obtain insight into the complex social and psychological situation of the individual girls, and which 2) enable us to compare the data for different girls. The procedure we follow is to formulate possible categories which are based on our hypotheses but might be modified on the basis of indications emerging from the data (Glaser and Strauss 1967).

FIRST RESULTS

On the basis of the first results we have provisionally specified four categories I, II, III and IV. For each of these categories we shall summmarize parts of the four interviews to illustrate the content of them and we shall comment on these contents. Finally we also make some comment on possible generalisations which we expect will be confirmed by the data derived from the other interviews.

I. The actual personal situation and future plans

Mabel: I have absolutely no idea what I want to do. Alas I've no idea. Perhaps I might get into the Academy of Dramatic Art, but it's not likely to get me a job.

My sister's going to be a nurse. That's not my line. My brothers have already left home. I don't know if they took physics at school. I never asked them about physics.

Elsa: I want to work in a hospital lab. Really I'd like to be a doctor, but if that's not possible then I'd like to work in a lab. My father's a doctor and he's doing all kinds of wonderful things. My cousin's going to be a doctor too. But I'll have to study a very long time to become a doctor.

My father has talked to me about physics and he tells me how things work and how they're made. I have a little brother, he is ten. He asks me questions about physics and I am proud that I can explain things to him.

Celia: I want to work with children or with mentally handicapped people. My aunt and two of my cousins are doing that now. I once helped my aunt when a mentally handicapped boy stayed with her. I don't know exactly what kind of training-course there is, but I've heard it takes four years.

I haven't discussed my plans with my parents. My father is an electrician. Neither of my parents has had as much education as me.

José: I'd like to do something with languages, be a tourist guide (on long journeys) for instance. I'd rather work with people than sit behind a typewriter in an office the whole day. But I don't have to make up my mind before next year and perhaps by then I'll want to do something else.

Each of the four girls seems to take the subject of her future occupation seriously. Two of the girls have concrete plans. One of the others regret not having a concrete plan and the last girl mentions that she has one year left to make up her mind definitely. The girls appear to derive their most concrete ideas about their future from role-models in their environment.

Only one girl talks frequently about physics at home. This seems to encourage her to become interested in physics.

II. Expectations about physics education and ideas about physics in a general and a vocational context

Mabel: I didn't really know what physics was all about. I had no idea, I didn't expect anything in particular. Yes, I knew you'd be allowed to do things yourself and that seemed rather attractive. Yes it really is attractive. But we haven't done any experiments ourselves so far. But I believe we are going to do some soon. At least I hope so.

Experiments which I can do at home like cooking and evaporating water do not interest me. Doing real experiments on your own seems to me to be too difficult. And besides, I'm a bit clumsy.

Elsa: My father told me something about physics, but what I was taught at school turned out to be quite different. Probably it's the way it's taught.

My father told me how things work and how complicated things have to be calculated. But so far we haven't calculated anything in our physics lessons. I don't think I'll ever be able to solve real problems in everyday life myself.

Physics makes me think of something very complicated. I don't know... it has something to do with thinking, thinking about lots of little balls, figures made of little balls.

Celia: I thought the lessons would be very dull. I knew there'd be experiments sometimes, but I didn't realise that we were going to do them every time. Nobody said anything about physics before, but they did talk about chemistry experiments.

Physics is important for people in certain professions; building workers have to know all about materials, electricians have to know physics.

José: I didn't know what physics really was and what it was all about. Yes, I knew that we'd be expected to do all kinds of experiments, but I didn't know how. It has turned out to be more interesting than

I expected. We have to do everything ourselves instead of the teacher doing it.

Three out of the four girls seem to have had practically no information about physics before their first physics lessons. They are surprised at the content of the physics lessons. Three of the girls are attracted by the idea of doing experiments themselves. Two of the girls mention activities which they consider to be far beyond the scope of their own ability. Three girls mention implicitly or explicitly that they expect to find physics to be difficult. The girls' ideas about what physics is or what it is used for are very fragmentary; their ideas are derived mainly from their first physics lessons.

III. Plans with respect to school "careers" and balancing of related choices

Mabel: Well I'm thinking of dropping History and French, because History is no use to me and I hate French, but I don't know about Physics yet. It depends on how well I do in the subject from now on.

Elsa: I think I'll choose Physics and Maths. Although I'm very bad at Maths, everybody needs it. My mother says you're stupid if you drop Maths because you need it a lot. And with Physics I have no problems so far, so it seems obvious I should take it. My languages are also very good at this moment, so I'll certainly take those too.

Celia: For the kind of job I want, I don't need high qualifications, but the teacher and others said that the low stream was too easy for me. I'd better go into the higher stream and work a little bit harder. When I was twelve we had a profiency test and my score was very high. I think the teachers know that and want the best for me.
I can even go into the top stream because of my results, but I won't do that because my elder sister who did that failed last year and now she has to do form five over again.
If I can, I think I will take physics. It depends on my results from now on. If things go as they're going today I and if I go on enjoying it and get good marks, then I will take it.

José: When I was twelve I was advised go into the higher or even the top stream of secondary education. But at the beginning of the following year in form one I had very bad results.Later on my results were much better, so my marks were high enough for my to move into the top stream. But I only wanted to be in the higher stream. In fact I don't really know why I wanted that. Last year I first thought I'd have to go into the lower stream or repeat form one.
I don't think physics is important for my future. But if it turns out to be important, then I'll take it.

Two of the girls discuss their school "careers" and mention factors which influence their "careers" but over which they have no control. However on one point they really do weigh up two possibilities: should they repeat a year or should they move into a lower stream. Both girls opt for the latter course. All girls think seriously about choosing physics. In the first place they take into account the importance of physics for their futures. Three of them mention that good results are a fairly decisive criterion. Only one girl mentions that her choice will depend on her appreciation of the lessons.

IV. Self-esteem and achievement expectations regarding physics

At this moment we do not have enough coherent data to complete this category. The four girls are very hesitant about formulating specific achievement expectations. One reason they put forward is that they do not know how difficult physics is going to be and what will be required of them. However they react fairly vigorously to the question of whether girls' and boys' have equal ability for physics and they declare that girls and boys have the same or comparable potential for physics.

DISCUSSION

For the first three categories we can formulate some hypothetical generalisations to be tested with the data of the remaining interviews. The fourth category however is not supported by sufficient data and seems to contain too contradictory data for us to define these category more specifically and to formulate any generalisations for this category.
The data of category I indicate that girls of 13 in general secondary education in the Netherlands are already thinking seriously about their future occupations; some of them derive their ideas from concrete role-

models, others are only indulging in wishful thinking about their future. The ideas they have about various jobs and careers are very limited and are derived from incidental sources of information only. The normal career guidance programme does not begin till a year later. For these reasons the particular environmental situation of these girls determines their thinking about their future and hence what is important for them to learn at school. The data of category II indicate that before the physics course begins the girls generally have very little information about what to expect. They have a very vague idea on what physics is, and what role physics plays in different occupations. They have not yet made up their mind about taking physics as an examination subject, but they expect to find physics difficult.

The data of category III indicate that girls in our study consider their situation to be determined mainly by factors which they cannot control themselves, namely the results of a proficiency test, evaluation, marks and advice given by teachers and parents. This seems to contrast with our presupposition that the girls' situation is determined largely by the balancing of options. Possibly we shall find more indications about whether girls balance options when we come to analyse the rest of the interviews on the girls' experiences in physics lessons.

Notes:

[1] We thank Erik Ellinger for assisting with the processing of computerised data and we thank Sheila McNab for her help with translating this paper.

[2] See also in this book Ton Jörg et. al., A logitudinal study on the unpopularity of physics among girls, quantitative part.

[3] Plon is the Dutch acronym for the Physics Curriculum Development Project, 1972-1985, Utrecht.

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IS A GIRL-FRIENDLY PHYSICS CURRICULUM ORGANIZED AROUND THEMES ?

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ABSTRACT

A multidimensional strategy is needed to make the physics education less sex-polarizing.

In this paper we describe the results of changing the organization of the physics curriculum in the Danish gymnasium (upper secondary school, age 16-19). The teaching is traditionally organized around central scientific concepts. As this may be one of the reasons why so many girls reject physics, we organized the subject around themes that we dealt with for certain periods of time. We found that thematic teaching results in a higher motivation for both sexes, but the choice of subject is more important to the girls. Most girls prefer subjects that are seen as directly relevant to themselves, and which involve both feelings and intellect. They reject subjects of a more general, theoretical character.

As a result of the study, we propose some changes in the teaching of physics.

INTRODUCTION

This article is based on the results of our on-going work in cooperation with Karin Beyer and Mette Vedelsby in the research project: "Sex roles and physics education - an analysis of the sex-polarizing effect of the subject." We are teachers of mathematics and physics, and the project deals with pupils in the Danish Gymnasium (upper secondary school, age 16-19). In another contribution to the conference (1), the project is described in further details.

DISCIPLINARY VERSUS THEMATIC TEACHING

The traditional physics teaching in the Danish upper secondary school is oriented towards the scientific disciplines , i.e., organized around central scientific concepts and their relations. Although the teaching incorporates many examples of applications, the students often say that physics has no connection with the real world. Especially the girls are very little motivated to learn physics. We think that the orientation towards the scientific disciplines may be one of the reasons. As part of our project, we therefore taught two periods with thematic teaching. About 80 students were involved.

In our teaching we combined the traditional subject of "Heat and energy" with a theme called "Heat conduction and insulation" (later referred to as H). This subject was chosen because of its relevance to the problems concerning resources, and because of the possibility of making experiments with insulating materials, that are used in homes. This theme was taught throughout 7 lessons.

The other theme was "Our climate and the energy-balance of the earth" (later referred to as C). In this theme physics is connected to natural phenomena in our daily surroundings. We worked on this theme during 10 lessons.

Recently the theme of "Light" (later referred to as L), was taught to 125 students as an introduction to physics in upper secondary school. These students have not otherwise been involved in our project, and that is the reason why we only succeeded in obtaining an evaluation of the process from 3 of the 5 classes involved.

The theme included spectral analysis of some elements in the laboratory and of some star spectra, the electro-magnetic spectrum and the historical discussion from Newton to Einstein about the particle or wave-nature of light. In this theme emphasis was put on phenomenological and aesthetical aspects of our surroundings, some emphasis upon technical applications of various types of electromagnetic waves and finally we included a little history of science. This theme took up 40 lessons.

CONDITIONS OF RESEARCH AND DEVELOPMENT

It is difficult to compare the response of the students to the different themes - for various reasons.

L was taught as the first subject in physics in upper secondary school, whereas the other themes were taught after periods of traditional teaching. It is not possible for neither the students nor the teachers to distinguish between the influence

of a specific subject and the influence of previous teaching. The two themes, H and C thus both came after periods of tratitional teaching, but the latter of the two themes was taught in another way than the the first as a consequence of the evaluation of the first theme. We also observed, that the evaluation of a theme was significantly different, when we asked the students one year after the theme was taught from what they said just after having finished the theme.
Another uncontrollable factor is the enthusiasm of the teacher. A teacher, who has developed some new teaching material herself, will usually be more enthusiastic about that material, and her enthusiasm may lend itself to the teaching.
Because of the above-mentioned difficulties, we have chosen to focus on a comparison of the responses gives by girls and boys respectively to the same theme, instead of comparing one theme with another.

MOTIVATION OF GIRLS AND BOYS

Among the girls and boys who received both traditional teaching and thematic teaching, there was general agreement that the latter was the most interesting of the two.
In the theme H, girls and boys appreciated different aspects of the subject. Many boys had already at some point helped to insulate the family house or they were about to plan insulation-works together with their father. No girls had equivalent experiences. One girl had started up some insulation work together her father, but she quickly gave up as the work was uncomfortable. Quite a few girls expressed the opinion that the subject had been irrelevant to them, as they did not expect that they would ever be involved in that kind of work. This attitude however was less pronounced in the class, which had a majority (75%) of girls. In the other two classes the girls made up 40% and 50% of the pupils. Most of the girls, who expressed an interest in the subject amphasized the general aspect of the conservation of resources. Several girls explained, how they had helped change some habits at home to conserve energy. Others appreciated that they were now able to participate in discussions about the subject at home.

The themes of L and C both included several sections. We therefore studied whether there were any differences between the two sexes as to the evaluation of the various sections. The students were asked which sections they had found the most interesting, and they were allowed to choose more than one section.
In both themes the most popular section was common to girls and boys. In L the most popular section dealt with the whole electromagnetic spectrum from radio-waves to X-rays. In that section groups of students were to read various texts to find the essential properties and applications of one specific part of the spectrum. Finally they should give a lecture on it to the rest of the class. One might well ask whether the popularity of this section was due to the subject or to the method of working in group. In fact this way of working was much appreciated by the girls, whereas the boys did not like it.
In C a section about environmental problems (the depletion of the ozone-layer and the CO_2-problem) was the most popular with both sexes. In this case the way of working was not any different from that in the other sections.
Although there was general agreement among girls and boys about which was the most popular section in both themes, there were substantial differences in their evaluation of the other sections. Of the other sections in C the girls preferred a section on climate near coasts and on the continents and on various phenomena, such as why the ice melts so slowly in the spring, and why the sand feels much warmer than the water on the beach on a summerday. To a certain extent, these were phenomena perceived by the senses. The boys, on the contrary, preferred a more general and theoretical section on basic properties of electromagnetic radiation. In the theme of L, the most essential difference was that the boys found the section on the history of science to be one of the most interesting, whereas the girls found it one of the least interesting.
The above mentioned reactions indicate that most students, regardless of sex, prefer phenomenological subjects that have an obvious relation to their life. But contrary to the girls the boys also seem to take an interest in the more general and theoretical subjects. This conclusion is in accordance with the fact that the evaluation of the themes has shown that girls' interests center around a few topics. The boys interests are

more diversified.

INTERPRETATION OF THE STUDENTS' REACTIONS

We interpret the above patterns as a consequence of both the prevailing sex-roles in society and the different demands for the learning process from the two sexes, which may also be a consequence of the sex-roles.

The image of physics is perceived as masculine by both sexes. Therefore the boys will usually try to meet the demands in this subject. That means that they are not inclined to give up, even when the subject seems difficult or of little interest. In our project we have seen that boys generally expect that learning physics will qualify them for further studies and give them skills to be used in hobbies and in repair-work in the home. But when they enter upper secondary school, at the age of 16, they have already experiences from the typical boys hobbies, which demonstrate applications of physics and which give some basic practical skills that can be used in the physics classes.

Girls tend to have no technical hobbies, when they first enter upper secondary school, and the sex-roles in society do not give the girls a general motivation to learn physics. On the contrary, many girls are convinced that physics is completely irrelevant to them. They are not going to need that kind of qualification in their future work, and as to the practical/technical problems in daily life: "I can ask my father/brother/husband to do it!"

That means that physics only appeals to girls when they see the subject as directly relevant to themselves. The subject must be exciting, aesthetical or it must be directly related to essential problems like management of resources, pollution, etc.

The girls lack of motivation to learn about more general subjects in physics is not only a consequence of the masculine image of physics. The same phenomenon has been described in a study of biology-teaching in the Danish upper secondary school (2). Biology does not have a masculine image, and it is chosen by more girls than boys. In biology, however, girls also prefer knowledge about their body and about something that can be used in daily life, i.e., knowledge that can be related to their personal experiences. The boys are also interested in theoreti-

cal aspects, exact knowledge and social perspectives.
We see a connection between the girls' lack of interest in general theoretical subjects and their demands on the learning process. Through our project we have become aware of that girls pay more attention to the working process in class, than do boys. In interviews and questionnaires, girls usually give far more detailed and personal evaluation of the teaching. More girls than boys describe the process and the feelings they have been through in class. In the theme of L, the girls preferred all the learning-processes, where they themselves were active participants to the processes, where mainly the teacher was active. An analogous distinction was not found with the boys.

Our hypothesis is that it is essential to the girls, that they are allowed to be active (in the working-process) with many aspects of their personally. It is of the utmost importance to girls that they are not required to leave behind their feelings, when they enter the learning process. It appears that boys more easily leave out their feelings in the learning process. This ability to disconnect the affective aspects from the cognitive aspects in the learning process is in some ways necessary, when you have to learn about general and abstract subjects. The exclusion of feelings is also in harmony with traditional teaching methods in physics.

CONCLUSION

Generally thematic teaching results in a higher motivation for both boys and girls, but the subject of the theme and its perspective is more important to the girls. The girls prefer subjects that have a phenomenological character, and which they experience as directly relevant to themselves. They do not want to learn about more general, theoretical subjects or subjects with relation to the practical technical problems, which men usually take care of.
The boys are motivated by all the above mentioned subjects. In this article we have pointed out some of the reasons for the broader motivation of the boys. Boys think that physics gives them qualifications to a broad array of educations and to their leisuretime too, and they do not, to the same extent as girls, have a need to involve feelings in the learning-process.

We think that these different attitudes ought to result in the following changes in the teaching of physics.

Firstly, we must develop methods to demonstrate to girls the necessity of going through difficult learning processes that may seem impersonal and purely intellectual at first hand, in order to obtain the tools required to reach a goal, which is relevant in the long perspective. We must thus make girls experience short periods of general and theoretical learning, which result in a knowledge, that is clearly relevant to them, and which cannot be obtained otherwise.

Secondly, the girls rejection of subjects in which they cannot get involved with both feelings and intellect, and which they do not find relevant, should be turned into a constructive criticism of a teaching tradition where feelings are usually considered irrelevant. We think, that an involvement of both affective and cognitive aspects of the student's personality in the learning process is essential, if school is to successfully educate the young generation to deal with technology in a more responsible way than is now the case. We do not want technicians who deny the role of personal commitment and responsibility in the evaluation of technological alternatives. Therefore the recognition of the role of the affective components of the learning process in physics education is equally important to the boys. Proposals as to how to integrate the affective and the cognitive aspects in physics education are put forward in another contribution to this conference (3).

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(3) Mette Vedelsby: "Some proposals for integration of affective and cognitive aspects in physics education" GASAT 4, 1987.

" ARE CULTURAL BARRIERS, THE PROMOTERS OF SUCCESS OF GIRLS IN SCIENCE AND TECHNOLOGY IN INDIA ?

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ABSTRACT

Women's role in science and technology is being recognized. However, their potential is not being sufficiently tapped for constructive purposes. This has led to global search for identifying factors which prevent women from achieving excellence in this field. The findings of attitudinal study conducted on Indian girls, in this regard are encouraging. They want to enter science and technology with determination. The cultural barriers are there. Role model inhibit their progress, but the mystry of their higher achievements in the university examinations lie in the inhibitory role models themselves. The girls defuse the cultural barriers and sublimate them for their success.

RATIONALE

This paper synthesizes in all three studies conducted by the author in the recent past. The findings of these studies are so integrated (and also reconciles, if possible) with those of other researches reviewed by the author. Although the conclusions that follow are the expressions of the investigator's personal interpretations of the findings and as such vulnerable. Care has been taken that they do not get polluted by personal biases and ideosyncracies.

Pandit Jawaharlal Nehru, the late Prime Minister of India stated, "Our civilization, our customs, our laws have all been made by man, and he has taken a good case to keep himself in superior position to treat women as chattel and pawn to be exploited for his own advantage". The constitutional provisions exist to prevent exploitation on the basis of sex. But, the nature and amount of its impact remains indeterminate. He wanted to see India emerge, a technologically advanced nation. To this end, he funded the public sector undertakings and created a infra-structure for future technology to grow. Even if, India has lagged behind in certain respects, it has the wherewithal of transforming the Indian traditional society.

The highest aspirations of traditional parents in India are expressed in a wish to get their daughters married. The higher education for them lay in improving their daughter marriage-prospects or to fill in the gap that lapses between their passing the high school and marriage. So, higher education in science and technology has gradually become the culturally moded social role of boys alone. Even in western countries women were permitted their entry in science and technology to serve as better house-wives or mothers (Manthorpe, 1985). It was a deliberated effort to improve girls manners and morales, as also to train them in domestic accomplishments. But in India the entry of women in science and technology could not even be debated in Parliament before her achieving independence in 1947.

The charge that Indian girls have been placed in the secondary position and that the social role models reserve for them two exclusive functions. These were only to "bear and rear children". The objectives of higher education (1949 in lieu were formulated in line with those role models, one that of a mother and the other that of a wife, to make them active and effective participants in the process of economic development. These roles have also been preferentially conceded to by women in India. But, the girls education in India has a long tradition. They are not the first or second generation learners. They are now competing with men in securing jobs in banks, railways, police, administration, engineering and in other occupations, so far termed as 'Males'. The university girls are seen capturing not only the university positions in the merit list but also the trend displays an edge of women over men. Their potential is being recognized. Their superiority uphailed for their achievements in the university examinations. The barriers of culture so far illumined by modernists and critics of Indian culture seem to liquidate. Are these mores and customs not potential enough to induce girls to opt science and technology for their careers ? The hunch in this regard perspired the following study :

" ARE CULTURAL BARRIERS THE PROMOTERS OF SUCCESS OF GIRLS IN SCIENCE AND TECHNOLOGY IN INDIA ? "

In pursuance of the intents of this study, the theme of the present paper is constructed to explore responses on the ensuing research questions :

(1) How do girls, boys, teacher and parents react against the barriers of culture imposed upon girls ?

(2) How do cognitive preference-modes hang-up with boys and girls achievements ?

(3) How do social role models and female role stereotypes substantiate their effects on the choice and achievement of boys and girls in science and technology ?

To begin with, the attainment of first part of investigation was a deduction appropriated through an attitudinal study. The subject sample comprised a significant number of teachers, parents, boys and girls, who were asked to react against certain constitutional provisions, as also against the biases constructed in the social order.

The constitution of India guarantees equality of opportunity for all citizen in matters relating to employment or appointment to any office in the state (Art 16/1); that the state shall direct its policy to provide its equality for adequate means of livelihood to both man and woman (Art. 39/1). that the state shall not discriminate against any citizen on the grounds only of sex, place of birth or any of them

(Art, 15/1).

The women elites from universities and colleges were unanimous in their report on points, however, a lapse of more than 3.7 decades of having adopted the constitution, women have not been able to fully utilized the fundamental rights conferred upon them by the constitution. This is why the women are the victims of covert discriminations. In this on going set up, the differentiation on the basis of sex, is not only carried out unofficially but also, informal means are at hand to bypass the well defined legal code. The social and traditional norms established for generations are too strong to permit any radical change, consequently women remain an exploited section of the society. They agreed that, in the post-independence-period, there has been a rapid expansion in the quantitative aspects of women education. They also accepted the feasibility of the growth of women-literacy from 0.69% to 27% during 1901 - 86. But, the comparative expansion of girls education in science and technology was rather disappointing. It leaves much to be described to come at par with men. The collegiate girls suggested that bases of education will have to be reoriented in order to bring about emancipation of women and obtain for them a rightful place in Indian constitution.

The collegiate male denounced the constitutional provisions as partial and biased in favour of girls. It denied due upliftment of the able. To them, it is a well organized conspiracy, a deliberate efforts to devoid boys of all the responsible posts. They can not imagine why so much of favour or preference is given to girl folk, even when, they are very much limited and poor in their knowledge. Their achievements appear high only because of the favour that male teachers show towards these girls.

The more important indicators that account for higher achievements of girls are the native cognitive preferences, 'social role models and role stereotypes', which apparently seem contradictory. The teachers attitude for this is positive. The girls have reasonably internalised the role models at their sweet will by living this life through generations. The parent elites (who were the subjects of study group) condemned the social roles as inhibitory in terms of girls progress towards scientific attitudes and literary tasks, but their reactions run counter from cold acceptance to extreme indifference, wherein 16.5% of parents elites reported that girls be given no education, 60.8% of them felt that girls should not be let in for higher education even if they were very intelligent. Even, a small group of affluent families opposed higher education for girls on traditional reasons. It is only a large section of this affluent society (12%) that regards the education of girls as an accomplishment and a symbol of modernisation.

It was in this regard that opting science and technology was appreciated as the need of upper middle and higher classes. They only make sacrifices for their daughters education to study science and technology. The findings also reveal that education of women in question as it is certainly negated by a variety of socio-economic and cultural inhibitions. As a result women in India have not been allowed equal access to educational systems. Unequal participation in all events is culturally enforced. Still the girls achievements are superior, which we find reflected in their superior educational effects in life chances. Inequality of status is all pervading phenomenon which even constitutional provisions have failed to repair. Long since the girls have been impressed that science is not for them but they are entering science and technology with determinations. The inhibitions like reluctance and general indifference, the traditional notion that the role of a woman is to bear and rear children etc. are not ignored but sublimated for higher achievements.

The Study on Cognitive Styles

The studies in the multi-dimensionality of learners cognitive functioning in recent years have provided a considered basis to explore the anomaly seen arising between the achievements and attitudes of girls towards science and technology. To refer Brooke a significant relationship existed between cognitive preferences and individuals satisfaction scores (Brooke, 1975). The potential value of the study of cognitive preferences, both for boys and girls was realised.

The findings of Pinchas Tamir, as also of Kempa and Dube, authenticated that high achievers tend to exhibit strong preference for (Q) the critical questioning and a weak one for fundamental principle (P). But, the findings of this study are a departure in the sense that high achievers tend to exhibit high loading with 'scientific curiosity' mode $(\underset{+}{Q} -- \underset{-}{R})$. While the low achievers were seen enamoured with 'scientific utility' mode $(\underset{+}{A} -- \underset{-}{P})$. The students selecting comparable dimensions of the subjects : Physics, Chemistry, Zoology, and Botany; data along four preference modes was gathered. The cluster analysis identified modalities of bipolar functions in the preference of boy and girls given in the following table :

S.No.	Factors emerge	PHYSICS		CHEMISTRY		ZOOLOGY		BOTANY	
		B.	G.	B.	G.	B.	G.	B.	G.
1.	Scientific curiosity.	R-Q + -	R-Q + -	R-Q + -	Q-R + -	R-Q + -	Q-R + -	R-Q + -	Q-R - -
2.	Scientific utility	A-P + -	A-P + -	A-P + -	P-A + -	P-A + -	P-A + -	A-P + -	P-A + -
3.	Technology	R-P + -	A-P + -						

The factors that emerge in the preferences of boys and girls are neatly comprehensive. Social role models seem not to impress any where. An additional factor 'Technology' that appears in the preference of girl, seemingly contradicts the thesis expounded by Harding and Benson (1985) that, "Science is a masculine construction from which women contribution has been excluded."

The male female duality of preference modes is settled in favour of girls. The factor 'Scientific Curiosity' crystallises dominating all the preferences of girls for the subjects : physics, chemistry, zoology and botany. The 'Utility' aspect seems to dominate the cognitive preferences of boys. The girls appear more inquisitive while boys are more utility oriented. These findings like Harding (1985) claim; "Science has social implications correlates with girls choice of it". Further, the findings seem to rebut, Whytes three deficit models : the genetic, cultural, and bi-cultural women are in no way, deficient in any of the attitudes, the performances and the choices they make. Even Harding or Hanson did not suggest female inferiority. Deficiency rather than strength to achieve high is divulged. The poor representation of girls (4.3% to 3.3%) does seem to reflect the cultural inhibitions.

Study of Social Role Models and Female Role Stereotypes

Lewry, Chen and Tamir in a study conducted on school going children of mixed-parentage of Israel found a 'gender-gap' between the boys and girls. The girls had more favourable attitudes towards science while the boys had the higher achievements. But in a similar study conducted by the researcher in India on collegiate girls the trends were partially contradicted. Along with highly favourable attitude the girls have superior achievements. The poorer achievements of girls in science were attributed to girls socialisation towards 'passivity'.

The women in higher education in India belong to upper and middle classes and cherish a life of leizure and home making than the life of work. Their attrition from the study of science and technology is natural. But, the higher achievements expound a phenomenon that changes girls attitudes towards science and technology or any of the educative function immediately after their marriage. To some extent the phenomenon of 'socialisation towards passivity' hang-up with Indian girls also. Such unusual occurrences were sought in the role models and female role stereotypes.

The findings in this regard were revealing. The majority of girls lack a role model. The girls in India from the very childhood are so well domesticated to social norms that anything beyond it; they feel is sin. The two role models : one that of a mother and the other that of a house-wife inherently shape womens career. When exposed to testing situations; some pseudo role models are reported. 'They would rather choose a professional life than a female role stereotype': that she would rather engage in research

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than in bearing or rearing children, "that she would better like to lecture in a class room than hearing reproaches of husband or in-laws etc. To them no subject is masculine, feminine or neutral but the choice of a subject or career depends on the capability of the individual and family circumstances. Inspite of their high proclamations, and aspirations, the range that they will find a job does not exceed 16%.

In the light of these findings, it appeared that the culture imposes barrier upon the achievements of the girls. The study of the girls perception of the barriers was significant. A large proportion (82%) report that there have been no cultural inhibitions. The seemingly traditional barriers as 'restriction on unwarrantted movements', 'more of domestication', role stereotypes etc. "Only help us go ahead, that freedom from restrictions and reservations sometimes cause in us unhappiness and induces a feeling of insecurity." "Our customs and traditions are all male dominated." He super-imposes the traditional laws by interpreting them in his own ways. There have been able ladies, whose self sacrificing zeal, unassuming loyality and strength in suffering .. .. are the glories of ancient years" (Dr. Radha Krishnan, 1964). Alienating women from traditional social values would mean pushing them to trends and ways of men and thereby, develuing them to the status of man. This may finally lead us to maladjustment, conflicts and confusion of non-conformation". They claimed, "Our achievements have perspired through our own habitual toil. Our culture, our rearing practices and social bindings have shaped our ingeneous overt behaviour." The barriers of culture were, therefore, promoters of their achievements.

Prior Experience: A Factor Which May Contribute to Male Dominance in Science

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Introduction

That the general issue of gender effects in science achievement remains one of current interest can be readily ascertained from the continued expansion of the literature in this area. While considerable attention is still being paid to the documentation of the nature of the differences between the performance and enrollment patterns of males and females in selected science areas, the debate over the sources or 'causes' of some of these differences has become the more central issue. We will not review the arguments put forward by various authors to support either a 'nature' or 'nurture' position since excellent summaries of these agruments can be found in the literature. Suffice is to say that most authors attribute at least some of the difference in achievement scores and enrollment to 'nurture'. The present study was undertaken to follow up on the proposition that the 'nurture' agrument is an essential component of an adequate explanation of the sex-related differences -- that differential prior experiences tend to favour the performance and attitudes of males in the domain of the physical sciences.

More specifically, the present study was designed to explore more systematically some of the conjectures made by Erickson and Erickson (1984) in their account of sex-related achievement scores. They examined a number of items in a large scale achievement test that displayed substantial gender differences and proposed that some of the observed differences could be explained on the basis of the item context. Those items which were embedded in a context that was much more familiar to males (ie. was part of their "sphere of experience") seemed to convey an advantage to the males by allowing them to construct more plausible responses to the items even if they did not 'know' the answer from their school experiences in science. The primary intent of the present study then, was to provide more direct evidence of the effects of prior experience on test-item performance.

Statement of the Problem

This study was designed to answer the following general question:

> Can the sex-related differences, which have been observed in selected science achievement items, be attributed in part to differences in the prior experiences of males and females?

In addressing this general question several more specific questions were used to guide the collection and the analysis of the data. These specific questions are:

(a) Do the students draw upon any prior experiences when they attempt to answer science achievement items?

(b) Can the students' explanations of their responses to the items be categorized? Are there any sex-related differences in these explanatory categories?

(c) Does the item context account for any sex-related differences?

Methods

Data Collection

There were two related data bases generated in the study. One was obtained from a sample of 238 grade 12 students selected randomly from three schools in the Vancouver Public School system. These students were administered a 23 item multiple-choice questionnaire. The 23 items had been used earlier in a larger province-wide Science Assessment in 1982 and had yielded a gender difference of at least ten percentage points or more in that Assessment. (That is, the percentage of males obtaining the correct answer on the item exceeded by ten points or more the percentage of females obtaining the correct answer). The questionnaires for this study were administered by classroom teachers to the students in their English or Consumer Education classes. (These were the only two compulsory grade 12 subjects at the time of the study). The results on these questionnaires were then used to obtain comparison scores between the sample and the grade twelve students who had written the Science Assessment test in 1982.

A second data base was obtained by conducting in-depth personal interviews with 15 (8 males and 7 females) of the 238 students who had completed the 23 item questionnaire. The 15 students, chosen from a larger group of volunteers, were deemed to be a typical cross-section of students. The interviews were conducted within a week from the time each student had completed the original questionnaire. These interviews then, were designed to identify potential linkages between the students' prior experiences and knowledge and their cognitive responses to a multiple-choice item.

The interview protocol was based on the items on the questionnaire. A brief orientation period was used to set the students at ease and explain that we were interested in their ideas about how they arrived at their answer and not whether they had the 'right' answer. The students were then given their own unmarked questionnaire so they could review each question and their response to it. Once the interview proper began the students were asked to reread each question and their answer to it. They were then asked some variation of the following question: "Could you remember what you were thinking when you answered this question or can you explain why you chose this answer?" The interviewer often asked for further elaboration of their response depending upon the nature of their initial response. These interviews were recorded on audio-tape for later transcription and analysis. Illustrative excerpts from some of these interviews are provided in the Results section.

Data Analysis

In the written questionnaires completed by the large sample of students the items were scored according to correct and incorrect answers. The results indicated that 21 of the 23 items had a 10 or greater percentage point difference in favour of the males. The item means were similar to those reported in the 1982 provincial assessment study.

Analysis of the interview data focussed on the explanations offered by the students in justifying their responses to a given item. First, a preliminary list of all the reasons offered by the students was prepared. These reasons, many of which were experimentally-based, were then grouped into four categories: school-based experiences, informal experiences, common-sense, and a miscellaneous category and each students' response for each item was placed in one of these 'explanatory categories'.

Results

The first of our research questions, regarding the students use of prior experiences in an interview situation, can be answered in the affirmative. The students frequently referred to a wide range of experiences when they were asked to explain how they arrived at their response choice for each of the 23 items.

The second question addressed the issue of categories of explanations and sex-related differences in the frequency of use of these categories. Of the four categories, the first, "school-based experiences", is self-explanatory. Whenever a student referred to some knowledge or an experience related to some previous school activity then it was classified in this category. For example, a female student responded to an item on the appropriate laboratory procedure for diluting acid with, "Well, it's something I remember my teacher telling me to do -- you always mix the water with the acid". (It might be noted that an appeal to some school-based experience often did not result in a 'correct' answer, as in the foregoing example).

The second category, "informal experiences", included references to experiences or events such as hobbies, playing games, television, radio, and recreational reading. In other words, experience obtained out of school. For example, a male responded to a graphing question on distances travelled when braking a car at different speeds by stating, "I based my answer on how long it takes me to stop in a car."

"Common sense" was the third category and it included references to knowledge that the student held but could not identify its source. A number of students made statements such as: "Well, that's just basic knowledge. Something I learned a long time ago." Or, "This sort of made sense to me. It was logical."

The final category, "miscellaneous", included responses in which the students had guessed at the answer, where they indicated that they couldn't remember how they had obtained an answer, or they worked out the answer by a process of elimination.

Table 1 compares the explanations offered by males and females across all of the questions. This comparison suggests the females tended to rely much more on an appeal to school-based experiences than did boys (54% to 36% respectively). It may be tempting to conclude that this finding represents a type of deferential posture on the part of the females in appealing to some form of authority, a hypothesis which can be found in the literature. However, we would argue this is not the only interpretation supported by our data. Since most of the items on the questionnaire dealt with aspects of experience we tend to associate more with boys than girls, an equally plausible interpretation is that lacking any out of school experience with the phenomena, the females were forced to try and remember fragments of experience and/or ideas from their previous science classes that might in some way be related to the question they were answering. In contrast, the males appeared to be in a better position than the females to draw upon their formal experiences and common sense in explaining their responses (43%

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Table 1

Percentage of Males and Females by Explanatory Category

	N*	School-based Experience	Informal Experience	Common Sense	Misc.
Males	184	36**	21	22	22
Females	161	54	16	14	16

* Where N refers to the total number of item responses by the eight males and seven females interviewed.

** Percentage figures are rounded off to the nearest whole number.

to 30% respectively). Given this situation it might be expected that since more than half of the female responses were based upon school-related experiences they should have outperformed the males. This was not the case, as the data from the large sample indicated. On only one item out of the 23 did the females outperform the males (by 2%) and the success rate on that item could have been obtained by guessing along (22% to 20% respectively). And, as indicated earlier, on 21 out of 23 items the percentage spread was 10 points and greater. Thus the attempt to draw upon memories of school-related experiences did not seem to confer an advantage to the females. The males, on the other hand, would appear to be in the more enviable position of having a greater scope of experiences to draw upon for these particular questions at least.

The final research question focussed on the item context as a potential source of sex-related differences in the explanatory categories. This question was addressed in two ways. The first was to examine the conceptual content and the gender distribution in the explanatory categories for those items displaying the greatest differences. The second approach was to examine the content of a number of items that elicited a spontaneous, negative response from many of the female students who were interviewed.

In the survey of 238 students, we found, as might be expected, the well-documented pattern that the females were much less successful on items which required a knowledge of physics and chemistry, particularly as it pertained to laboratory-type situations. For example, on a question asking the purpose of a fuse or circuit breaker the males significantly outperformed the females (66% to 35%). In describing the reasons of their answers 6 out of the 7 females interviewed referred to some type of school-related experience to justify their response. An illustrative female response was:

> "I know what a circuit breaker is. It makes things go in two directions. We did it in grade 10. I wasn't into it. I didn't put it in my long term memory. It was a little tedious and hard for me to understand."

On the other hand, only 3 out of the 8 males interviewed used this category, the other 5 referred to some sort of informal experience such as,

> "That I know from stuff around the house. Fuses blow in our house all the time. I usually go downstairs and switch the breakers."

Other items such as identifying the type of substance that must be kept away from an open flame yielded similar results.

Close to half of the items elicited an immediate, negative response from one or more of the females interviewed, whereas only one male responded negatively and to only one item. Typical spontaneous female responses to an item which showed a picture of a bunsen burner were:

> "Bunsen burners scare me. I never did learn how to use them."
>
> "I never want to light another bunsen burner again. They scare me."

These negative kinds of responses may have 'blocked' any serious cognitive engagement with the item often resulting in the females simply guessing at a response rather than trying to reason or to even recall some type of experience that might be of some assistance to them. This affective disposition towards many of the items along with an underlying uncertainty or lack of confidence that accompanied the females' explanations, would seem to put them at a disadvantage compared to their male classmates in achievement test situations of this sort.

In conclusion, we would submit that these data, albeit from a small sample, illustrate the differential effects that different prior experiences can exert on test performance scores for males and females.

References

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Girls and New Technology

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Since the end of 1985 a combined research and development study on girls' education and new technology has been going on in Hessia, West-Germany. The experience and results of this work are supposed to be integrated in the plan of a Hessian basic training concerning information and communication technology.

The starting point of this research work is the hypothesis that girls and women have a different access to science and technology which up to now has not been asserted neither in corresponding lessons nor in job practice. Thus the alleged desinterest in science and technology as well as an underrepresentation of women in this field has been the consequence.

The special interest of the study is to find out the different motivation of girls in computers and new technologies and the way they might handle it. The goal of the study is to change the usual methods of teaching science and technology in a way that does not any longer discourage girls. Therefore the content of this work is to carry out and theoretically assist lessons about "Introduction to a Critical Way of Operating Computers" in the 8th grade of two comprehensive schools (additive Gesamtschulen) in Frankfurt/Main.

The first methodological way to find out different interests as well as the attitudes of girls and boys to the relationship of

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"women and technologies" was a survey we did in spring 1986. Group discussions were held with students who correspondingly are tought in the school year of 1986/87. Topics of these discussions, held in sexually homogene groups, were as follows:

- experience with computers
- assessment of girls'/women's relationship to new technology
- necessity of computer use in schools
- computer courses especially for girls.

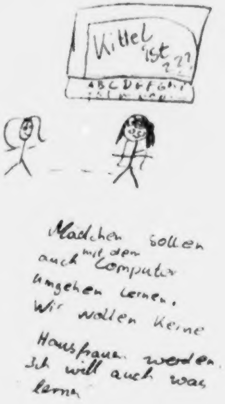
These discussions began with drawings made by the students and which werde also used as a starting point of the discussion.

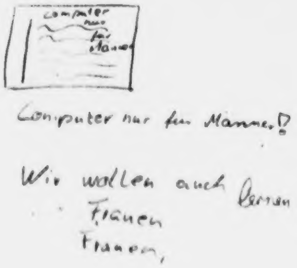
Some results of these discussions shall be summarized especially concerning girls' interest in this subject as well as the relationship between boys and girls.

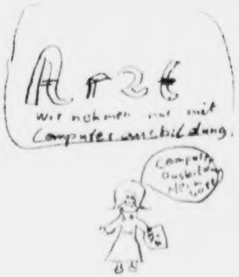
There is an almost unaminous girls' interest in computers. Eventhough fun or anticipated fun is of great importance the assumed necessity of appropriate qualification for a later job seems to be more decisive. Some girls had the hope of escaping a future housewife status by being involved in computer operation. A lot of them were afraid of being "shaken off" on the later labor market because of not having sufficient qualifications. The following drawing of a high school girl (Gymnasiastin) reveals to all of those aspects (Figure 1). She comments:

"On my first picture I've drawn a computer and a girl, who is looking at the computer and doesn't know, what that is. And there is another girl coming up and explaining it to her. And because of that, the first girl is getting motivated in learning how to use a computer. And she says: 'well, I don't want

Figure 1:


Kittel ist ???
ABCDEFGHI
Madchen sollen auch mit den Computer umgehen lernen,
Wir wollen keine Hausfraun werden.
Ich will auch was lernen


computer nur für Männer
Computer nur für Männer!?
Wir wollen auch lernen
Frauen
Frauen,


Arzt
Wir nehmen nur mit Computerausbildung.
Computer ausbildung Mein Gott

Girls should learn too how to use computers.
We don't want to become housewifes.
I want to learn too.

Computer for men only !
We want to learn too
Women

Women

M.D.
We employ only with
Computer-diploma'

Computer-diploma -
My Gosh

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to become a housewife ... and that's why I'ld rather like to improve my abilities in using a computer.'
And the next picture, I've drawn a computer or something like that and wrote on the screen: 'Computer are for men only !' And I don't know, I wrote underneath: 'Computers are for men only ? We want to learn too !'
And on my last picture, I've drawn a sign saying 'Medical doctor' and underneath it says 'We employ only those who have a computer-diploma'. And the girl is standing there and saying: 'Computer-diploma ? My gosh.' And she is crying." (Gr. 2 GS, p.2)

The girls also discussed the ambigous effects of computer use in the field of labor. Hence unemployment is realized as a possible consequence as well as an enforced competition in the meaning of displacement. Considering such expectations as background the girls are not absolutely sure whether work with the computer will virtually be of use for them.

The part boys play in the girls' process of sorting themselves out is a further aspect for interest in computer work besides the potential fun and the anticipated necessity for later job prospects: To know that boys do not believe girls to be capable of handling computers is a challenge to their resistence.

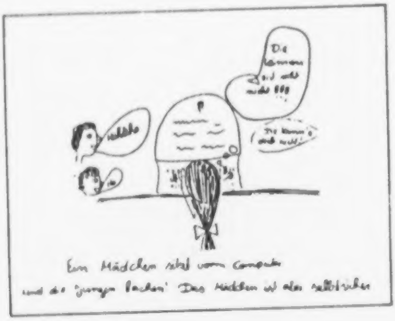
Above all elementary school girls (Hauptschulerinnen) show fear of incapability which enforce their interest in better qualification, though.

Experience and assistance are essential in this process of gaining competence and self-confidence. Such assistence, however, is hardly to be found on the part of the boys. Thus one of the main subjects of the drawings and the following discussion was the tension between the boys' rejection and the contempt of the girls and on the other hand the girls' self-assertion as well as the girls' lack of self-confidence regarding this opposition:

Very often girls drew boys discriminating them and also wanted to discuss such experiences (Figure 2). The high school girl who drew the figure 2 comments:

"Well, there is a girl sitting in front of a computer and the boys are saying: 'Look at that, she cann't do it in no waz, ha, ha, ha'. The girl is thinking though: 'It is them who are unable to do it.'" (Gr. 3 GBS, P. 1)

Figure 2:


Ein Mädchen sitzt vorm Computer
und die 'Jungen lachen' Das Mädchen ist aber selbstsicher

Boys produced pictures one after another which showed girls helplessly standing in front of computers that indicate mistakes as well as pictures which expressed that girls should rather take care of their dolls and leave computers to the boys (Figure 3). Usually the boys did not verbally express such opinions - like the elementary school boy (Hauptschüler), who drew figure 3 only commented on his picture:

"First I've drawn a computer which is for boys only. The second picture is a computer, and the third picture is a boy and a girl." (Gr. 1 GS, p. 3)

There is no need to illustrate the climate which is caused by such attitudes.

Nevertheless the directly gender relation does not reveal all differences in the boys- and girls-students' attitudes and expectations. These differences concern the organisation of lessons but above all they do concern the subject, i.e. what the students are keen on getting to know about new technologies.

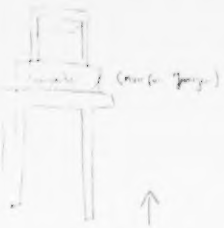
'To learn how to handle a computer' was most important for both sexes. This particular phrase appeared over and over again.

For the boys this meant above all the knowledge 'how does it work' beside manual instruction. Besides this interest in mechanics boys furthermore have the wish to learn how to program computers - which can not always be distinguished form playing with computers, though.

Figure 3:

For boys only

Nur für Jungen

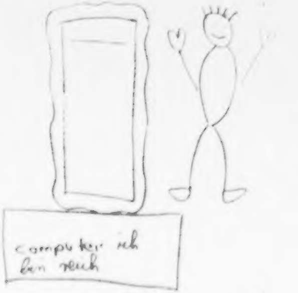


Aber, ich meine die Computer nur für Jungen sind

Here it is my opinion that computer are for boys only

I am better

Ich bin was besseres

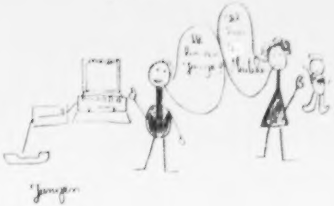


Aber, hier meint ich, wenn ein Junge ein Computer hat meint er wer was besseres

Here I say that boys who owe a computer think of them as better people

Everybody to where he belongs

[illegible]



I am a boy

doll

I am a girl

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There are quite a lot of girls too who would like to know what a computer looks like from inside, but this interest rather stays behind. 'Handling computers' does not mean 'knowing the mechanics', but just a critical 'registering them for use'. Girl do not refer to the anticipated lessons by considering the devices in the first place. They also want to learn out of books and discuss matter and facts. Such procedure is almost out of question for boys.

As a conclusion out of the presented results and experiences there are above all two main questions regarding the problems of planning and arranging lessions:

How to change the boys' social behavior in such a way that there is a possibility of loosening this tense relation between the sexes ?
We visited quite a lot of different lessons in practice and we found very different ways of social behavior in girls-groups and in boys-group. Boys very often disturbed each other and worked competitive, girls usually helped each other.

What can integrated lessons look like that link work with computers as operation and experience to a social scientific understanding of the changes that take place ?
We proposed two different ways for this up to now:
On way for example is to start out with a word-processing-program and first let the students try out the use of it. After that they compare word-processing with writing in other ways (like with feathers, pencils, pens, type-writer). They are shown the historical development of the technology as well as

the use of it in different occupations. In each case we especially relate to the role of women.
Another way is to start out first using and changing a little basic-programm, continuing then with LOGO. This is to compare different ways of programming and to find out, that computer never function without a programm. After that the students should be shown the different ways of using computers as universal machines and be able to reflect the problems that go ahead with their use.

Up to now we have not got an answer to either of the two questions quoted above. But we can be sure that not answering and hence not paying attention to the differences due to gender will lead to blocking the existing girls' interest in the particular teaching process. Whereas the boys' interest will be able to be pushed through - on account of a critical aquirement, though.

SOME REMARKABLE GENDER FINDINGS ABOUT LEARNING THE PHYSICAL SCIENCES IN THAILAND

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INTRODUCTION

The problems of girls' under-achievement and also under-representation in the physical sciences at school have been widely documented in a number of western countries like U.S.A. (NAEP, 1978; Gardner and Yager, 1983), the United Kingdom (Kelly, 1976, 1981; Harding , 1979; Cornelius and Cockburn, 1981), Canada (Hobbs and Erickson, 1980; Erickson and Erickson, 1984) and in Australia (Parker, 1984; Ives, 1984). Gender-differences in favour of boys were obtained from the studies in all these countries. In those countries where other measures such as attitudes to science (Gardner, M., 1973; Gardner, P. 1985) interests in science (Wilce, 1982, Kahle and Lake, 1983) and preference for practical work in science (Omerod, 1981) have been done, and the findings also parallel the lower-achievement of females.

The evidence from these sorts of studies has seemed to be so consistent that some have even suggested that it is unlikely that girls can do as well as boys in science. For example, Gray (1981) suggested that a biological factor may give males an advantage.

Among other theories that account for the lack of success of females in science has been the masculine image of science and socio-cultural factors, Weinrich-Haste (1981) in England and Feldman (1974) in U.S.A. found that chemistry and physics were seen as masculine. Erickson and Erickson (1984) have suggested that cultural factors leading to differential experiences account for these differences.

A few studies from non-western countries have appeared that suggest other sorts of findings, but they have rarely been extensive enough to determine the outcomes of girls in learning science. They do, however, provide evidence that females are not always under-represted in the physical sciences (Kelly, 1981; Walford, 1983; The Royal Society and Institute of Physics, 1982).

Since extensive data that boys out-perform girls in physical science learning exist for western countries, there is a need to look at some non-western countries to see whether the same patterns of lower female achievement exist. Factors that operate on science learning in a developing country like Thailand, the source of this report, may be very different from the western countries that have hitherto been the source and centre of this gender debate.

Thailand is a developing country in South East Asia of about 60 million people. It has put a great deal of effort into science education for its school since 1970. The Institute for Promotion of teaching Science and Technology (IPST), a national centre, was established to be responsible for the science, mathematics and technology education of the country. A succession of curriculum development projects have been undertaken by IPST staff so that by the early 1980s IPST science curricula (some already revised) were in place at every level of the Thai schooling system. This system is indicated schematically in Figure 1.

Level	Year	Academic schools		Vocational School	Age
		Science stream	Non-science stream	Specially designed Science course for each vocational programme	
upper secondary schooling	12 11 10	Physics Chemistry Biology	Physical-Biological		17 16 15
lower secondary schooling	9 8 7	General Science (all pupils)			14 13 12
compulsory primary schooling	6 5 4 3 2 1	Science as part of Life Experiences course (all pupils)			11 10 9 8 7 6

Figure 1. The structure of schooling in Thailand and its organization of science curricula.

For each level and sector in the system there is a specially designed science curriculum and the students in all these sectors are required to study science using in each case the appropriate curriculum materials.

Students entering the academic schools in the upper secondary sector almost invariably remain for its three years of study. They have to declare their intentions for the science or the non-science stream, but those who opt for the so-called "non-science" stream have to study its science curriculum for 6 semester credits. The majority, who choose to be in the higher status science stream, have to study all three science subjects, namely physics, chemistry and biology in each year (10, 11 and 12). The students in the various vocational schools all have a science curriculum which is specifically designed to support their vocational goal.

This brief review of the structure of the Thai schooling system is intended to illustrate how science has been taken very seriously as part of a total curriculum of all school pupils. Among many consequences, it does avoid the problem that students in the later years of secondary schooling may choose not to study science or simply to study biology both of which have happened in other countries like Britain, Australia and U.S.A. (Fensham, 1986).

Nature of IPST Science

IPST science curricula for Biology, Chemistry and Physics represent a revolution compared with the traditional science curricula used in Thailand prior to 1975. In these new curricula, the three main characteristics of science included in their development are (i) the gathering of scientific knowledge, (ii) the practice of scientific inquiry and (iii) the development of scientific attitudes. Thus, the courses and their materials are designed so that they are activity-based, involving quite novel aspects of inquiry and discovery, and they are learner-centered in orientation. Laboratory work becomes an essential part of these science courses since through it the theoretical and practical parts are to be integrated. Students in groups of three are required to perform experiments on a regular basis (usually two periods out of five per week), to observe, to gather and organise data, and to interpret and draw conclusions from data obtained in experiments. These processes are meant to be emphasised throughout the three years of each science course. Although these curricula were developed in Thailand, it could not be claimed that all the ideas originated there, because many are borrowed or adapted from the curricula available elsewhere, e.g., from U.S.A., CHEM Study (for Chemistry) and PSSC (for Physics), from U.K., Nuffield Science Projects and from Australia, ASEP. It can be argued (Fensham (1986)) that IPST (and Thailand) was able to optimise not only the collective ideas of the reform movement in science curricula, but also to learn much for their own implementation from the rather painful and disappointing lessons these other western countries experienced.

Examination of the content of the science to be learn in the three senior science courses would not show many obvious differences from the treatment of the same topics in the familiar curriculum materials of other countries. That is, they do not appear to have been redressed for gender bias in the ways that have been advocated by some western critics of science curricula. The physics text books, for example, still present a predominance of masculine images as do physics texts in many countries. The chemistry text books do not present much at all in the way of human illustrations. They are not human problem oriented as Harding (1986) has advocated, nor is there a particular emphasis, as Samuel (1981) looks for, of learning applications of science that are gender balanced in society. They are certainly not at all in the direction, as far as content is concerned, of the science that feminists suggest would be more appropriate for boys and girls to learn.

This is not to say that there are not other more implicit aspects of these curricula that are less gender biased than their counterparts in the west. For example, most of the chemistry development team (including six of its seven leaders) were women.

Gender and Chemistry learning in Thailand

In an initial study, the learning achievements of girls and boys in chemistry in the three final years of the Thai system (years 10, 11 and 12) were investigated. The primary purpose for this study was to investigate the efficacy of the IPST curriculum in fostering in students the three main characteristics mentioned above. As will be clear from the discussion below, the gender findings were so remarkable that they have determined the form of two other subsequent studies that also are reported in this paper. More details of the first study are reported elsewhere (Klainin, 1984, and Klainin and Fensham, 1987a). In summary, six schools in the Bangkok area were involved in the study. There were two girls schools, two boys schools and two co-educational schools. The subjects were the science students in two classes from each year level (10, 11, and 12) in the six schools and totalled 1481 students, out of which 767 were girls (51.7%) and 704 were boys. 250 girls and 244 boys were in the co-educational schools.

Seven sets of tests were used . Three are practical tests of Manipulative Skills (MS), Problem Solving (PS), and Observational Skills (OS). The other four are paper and pencil tests, test for ability to link practical work to knowledge of chemistry (LK), test for Source of Evidence (SOE), Knowledge Achievement test (KA) and test on Scientific Attitudes (SA).

The Manipulative Skills test required students to perform an experimental task involving equipment according to well defined instructions. The assessment was done by direct observation by three assessors who were trained to look on the same criteria. The assessors used a checklist for correct performance and an intermediate marking scheme based on the four criteria suggested by Kempa and Palmer (1974) for practical tasks. The test thus has five sub scales, Correct Performance, Experimental Techniques, Procedures, Dexterity and Neatness. Students in all three year levels were assigned the same task, which was chosen because it involved basic components of practical chemistry that these students should learn in their studies of chemistry. About half of the students in each class were assessed for this practical test while the rest of the class were also doing the same task without knowing that they were not assessed.

The Problem.Solving test was developed to examine the students' use of practical skills in the context of a problem·solving situation. It involves Planning a strategy of practical investigation, Manipulating apparatus and chemicals, Observing the results of tests on the chemicals, Recording these results, drawing Conclusions from them and Report Writing the investigation.

The Knowledge Achievement test consisted of three multiple choice sub-tests designed to examine the students' acquisition of knowledge and comprehension of facts, principles, laws and concepts. It was designed to correspond with content from topics in the courses in year 10 (KA_1), year 11 (KA_2) and year 12 (KA_3). The three sub-tests were administered to the students in each of the years.

The test for Source of Evidence is of a preference type and is designed to examine what the students think about as sources of evidence when they answer various questions. In each item there were four possible answers, for the students are required to choose one source from (1) Rules and Facts that are seen as generally accepted work of scientists, (2) Text books, (3) Laboratory Experiments, and (4) Teacher's word.

The Test on Scientific Attitudes (SA) used in this study is that developed by Kozlow and Nay (1976).

Overall mean scores and standard deviations are shown in Table 1. The scores for the boys and girls in the whole sample were compared for each test and sub-test, using a one-way ANOVA analysis. The analysis was then repeated with sex-in-type-of-school as a variable to provide four groups : (1) boys in single sex schools, (2) boys in co-educational schools, (3) girls in single sex schools, and (4) girls in co-educational schools. The Scheffe Ranges Test was used to ascertain where significant differences existed between the group means and these directions are given along with the group means in Table 2.

In addition, two-way ANOVA analyses with sex by grade level and with sex-in-type-of-school by grade level were used to examine the interaction effects between them.

In general, the results in Tables 1 and 2 indicate that the differences between boys and girls in chemical learning do not conform with the findings reported in similar studies elsewhere in a number of countries. Girls significantly outscored boys in six of the seven sets of tests and in the seventh (concerned with observations of chemical changes in the laboratory) there was no significant differences between the two sexes. The girls in the single sex school surpassed all other groups in the field of theoretical knowledge of chemistry, while the girls in co-educational schools showed they were the best performers in practical chemistry.

Most of the studies in chemistry learning reported from other countries have reported differences in favour of boys. The results in this study thus immediately raised questions about contributing factors that may be operating differently in Thailand from the possible factors that have been suggested in western countries in particular where a lot of details about such factors are available. They also raised the question of girls achievement in Physics, and whether in Thailand it would follow the same trend or would it be like the findings in other countries all of which report very clear bias in favour of boys.

Gender and Physics learning in Thailand

To respond to the question about girls' achievements in physics a second study using conditions and measures very similar to those in the chemistry study were undertaken in 1985/86. Five similar measures were used. These are Manipulative Skills (4 sub-tests), Problem Solving Skills (5 sub-tests), Knowledge Achievement in physics (3 sub-tests), Source of Evidence (4 sub-tests) and Scientific Attitudes. A detailed account of this study is being prepared (Klainin, West and Fensham (1987)).

The physics study again produced results that provide definitive answers to the question above. Overall mean scores and standard deviations for girls and boys, and their comparisons are again summarised in Table 3. The directions of significant differences between the group means for the different school types are presented in Table 4.

The results in Table 3 show that, in general, girls outperformed boys in the laboratory related outcomes. They, in fact, scored higher in all of the Problem Solving subscales and in Manipulative Skills overall (and in its Dexterity and Neatness subscales). They performed as well as boys in theoretical learning of physics, i.e., in the Knowledge Achievement measure and the differences from the boys in preference for Source of Evidence and Scientific Attitudes were not significant.

Type of school (see Tables 3 and 4) did show some effect on the students' practical outcomes. Girls in single sex schools seem to be the best group in practical physics; in practical chemistry girls from co-educational schools seem to be the best group. Girls in co-educational schools did better than the other groups in Recording (Problem-Solving subscale) and they outscored their boy classmates in Report Writing. Girls in single sex schools were the best group of learners in theoretical knowledge of chemistry. In physics no group scored significantly better than others in theoretical knowledge, except for the knowledge of grade 10 physics for which the girls in single sex schools were again the best group.

In summary, the results from Chemistry and Physics studies show that:

1. Girls perform at least as well as boys in physics and better than boys in chemistry.
2. In laboratory related outcomes (Manipulative Skills and Problem Solving) girls outperformed boys in both physics and chemistry.
3. Girls in single sex schools outperformed the other three groups in practical physics, and in practical chemistry, girls in co-educational schools outperformed girls and boys in single sex schools and their boy classmates in co-educational schools.
4. Girls in co-educational school surpassed the other three groups in Recording (Problem Solving subscale).

Students' Perceptions of the Sciences

In the light of the chemistry findings, and while the physics study was being prepared, it was decided that it would be useful to replicate the studies of Feldman (1974) in the U.S.A. and of Weinrich-Haste (1981) in Britain that reported that both boys and girls perceive the physical sciences of physics and chemistry as 'masculine' subjects.

In our study the boys and girls were asked to indicate how they perceived chemistry, physics and biology as gender preferred subjects. Both boys and girls responded with respect to biology and physics in ways that are very familiar in the western studies. Chemistry, on the other hand, was seen in a quite different way. A substantial majority of both the girls (79%) and the boys (66%) saw chemistry as suitable for boys and girls. Most of the others saw chemistry as more suitable for girls.

We also decided to explore whether they could relate the sorts of practical tasks they now encounter in their science studies to gender preferred roles in society. For details of this third study, see Klainin and Fensham (1987b). A list of laboratory tasks from chemistry and physics were presented and the students were asked to indicate whether they saw these as like men's or women's activities and why.

In general, most of the chemical tasks were seen by both boys and girls as predominantly like women's activities. Conversely the physics tasks were seen like men's activities. However, just a few of the chemical tasks were seen by both boys and girls like men's work. Among these is a key item to do with 'grinding solid chemicals in a mortar'. We will return to its fascinating response pattern later on in the discussion.

DISCUSSION

The findings for the learning of girls in chemistry and physics are different in a very positive direction from the findings that have been of such a concern in the west. These findings from Thailand suggest that girls can do at least as well as boys in (physical) science. In the area of practical skills girls have demonstrated better performances than boys. They performed equally well in the theoretical learning of physics and better in chemistry. In scientific attitudes they are not inferior to boys.

In discussing these results we can immediately refute any hypothesis involving biological factors that imply inevitable inferiority in these sorts of learning to girls. The findings, however, have much more to contribute to the topic of gender difference in science education.

Many factors have been suggested in the literature besides that unpopular biological factor. They are :

1. Organization of schooling and its time table
2. Teaching approaches

3. Family and societal attitudes
4. Science itself (particularly the physical sciences)

In the first place, it is suggested that the achievement of girls in Thailand is due to the organisation in the schooling system whereby all girls and boys are required to study science at every level of schooling and those who enrol in the 'science stream' are required to study each of physics, chemistry and biology. This organization of schooling avoids, as indicated above, the serious problem in many western countries of students choosing not to study science or simply opting for biology alone (Fensham, 1985).

It is, of course, a truism that if more girls were required to take physical science studies in western countries, more than at present would succeed in learning physics. They may not, in the absence of other supporting factors do as well as boys, particularly if the compulsion was perceived by them negatively. Since a number of these countries place a high value on "choice of studies" particularly at senior levels, this could well be the consequence of a compulsory requirement at least initially. That Thailand has combined required studies with successful learning by girls makes the societal correlates of compulsion there very worthy of study, but that is beyond the scope of this report.

The teaching approaches in Thailand, generally speaking, are not obviously intended to be different from those in the western countries. As was earlier mentiond, the ideas of an activity based curriculum and the content of science curricula have been largely adapted from Western countries. In practice, however, the great majority of Thai chemistry teachers are women (32 of 35 in our study), and there are about equal numbers of men and women teaching physics (8 and 8 in the study). Whatever effect role modelling by teachers in

Thailand may have (and their gender proportions are very different from those in most western countries), they are not by location distributed in favour of boys or girls. Nevertheless, it does seem to be true that girls in co-educational classes in Thailand are much more prominent participators in class discussions than their western counterparts are reported to be.

At least in Bangkok there is evidence that the recommended practical work in the laboratory of these IPST courses is regularly observed. Teachers and students from schools in different parts of the country have also indicated that the students do perform actual laboratory work as a regular part of their classes. It may well be that laboratory work in science classes in Thailand may be more regularly practised than in countries like Australia and U.S.A. where there seems often to be a considerable shortfall between what is practiced and what the curriculum intends. In some European countries, however, similar impressions suggest high levels of regular experience with practical science. Indeed the emphasis on practical work in science, with its expectation of tinkering confidence to use apparatus and measuring instruments has often been seen as a source of handicap to girls. The considerably expanded emphasis on practical work at all levels of science learning in Thai schools has obviously not acted in this way, and the regular experience in the earlier years may be an important factor in the success girls showed in practical tasks in our studies.

The third factor suggested is 'family and society' and the gender related perceptions of laboratory tasks by the Thai students do suggest that family and societal associations may have quite a strong influence on the students' learning in the sciences.

Students identified most chemical tasks as more women's work and a common reason was that they were very similar to cooking or kitchen work, neither of which in Thai culture is seen in general as male-appropriate. The habits of stirring, heating or boiling liquids, watching colour or temperature changes, etc., are more part of girls sphere of social experience - the sort of congruence Erickson and Erickson (1984) suggested could be an important learning advantage.

The key chemical item, 'grinding solid chemicals in a mortar' was seen as men's work. Readers familiar with Thailand will have often seen pestles and mortars, some of which are very large and heavy, the better ones being made of stone. The use of these mortars is a very integral part of Thai culture, since they are used to prepare the curry pastes of considerable variety (based on many herbs and spices such as dry hot pepper and lemon grass) that are so essential to eating in Thailand). The grinding into a fine paste is a difficult and heavy task and requires considerable strength. Traditionally it has been a duty for the men of a Thai household and, indeed, it is one of the very few duties for men in the kitchen.

In chemistry class, pestles and mortars are tiny ones and the grinding of a few crystals in them requires little strength and is equally accessible on these grounds to boys and girls. Nevertheless, both boys and girls saw this activity as being like 'men's work'. This item provides strong supporting evidence that students in responding to the questions in our third study have brought their social world into their science class.

On an overall view, it is found that girls from co-educational school out-performed other groups (e.g., boys in co-educational school and boys and girls from single sex schools) in practical chemistry. When it comes to practical physics, girls from single sex schools surpassed the other school groups. These successes of girls can be explained because students see chemistry as women's work. In chemistry class where boys and girls work together, the girls predominantly do the tasks while the boys stand back. In physics class, on the other hand, girls tend to draw back, and the majority of the tasks is being done by boys. In the single sex girls' schools there are no boys to compete with as to who will do the tasks. Girls in co-educational school also scored highest in Recording which includes making observations and recording them in systematic order. They are also better in Report Writing. It is not surprising to find this, because this type of work seems to be predominantly done by the girls during practical sessions in co-education classes.

Nevertheless, when girls work without the presence of boys in single sex classes, they have to carry on the job and they then show themselves to be equally capable or sometimes better. This suggests that girls are more adaptable in responding to the situations that face them. Schools in Thailand, because of the centralisation of curriculum, do not differ in terms of the programmes they provide for students. Moreover single sex schools for girls do have 'good' reputations and gain recognition from society and parents as well. These family and societial attitudes and expectations of these schools as places for quality learning may contribute to the girls' success in the science learning outcomes.

Finally, science itself (and particularly the physical sciences) is said to have masculine image. This, it is suggested, can be a deterrent to girls at a time in adolescence when they are forming their identity and image as females. Students in Thailand at least do not see chemistry in this way and indeed the images that students have of its detailed tasks appear to be deterrents for improving the success of boys in this subject.

These results from Thailand and the discussion of them in terms of a number of contextual aspects of the Thai school system and society may provide some explanation of the successful learning of physics and chemistry by girls in that country. Some of these aspects, no doubt, are culturally associated with Thai society and hence are not transferable to other countries. Much more research is needed to sort out what is transferable and what is not. Nevertheless, it is encouraging that girls do have the chance to perform well in science and they do so, at least as well as boys. They are not built to be less able in science as it was once said. It is suggested than an inclusive organization of schooling and its time-table can bring some benefits to girls' achievements in science. Expectations by teachers, parents and society more generally, that males or females are not different in their capacities for science learning, do seem to be making rapid progress in Thailand.

TABLE 1. Chemistry study : comparisons between boys and girls

Test	Boys		Girls		Significant Differences
	mean	s.d.	mean	s.d.	
Manipulative Skills (MS)	37.8	6.8	39.2	6.8	girls > boys**
Problem Solving (PS)	20.6	10.3	22.1	9.6	girls > boys**
Observational Skills (OS)	7.8	3.8	8.1	3.0	ns
Link Practical to Theory (LK)	4.8	3.1	6.3	2.7	girls > boys**
Source of Evidence - Laboratory (SOE)	5.0	2.5	5.8	2.7	girls > boys**
Knowledge Achievement (KA)	10.3	7.4	11.3	8.9	girls > boys*
Scientific Attitudes (SA)	19.3	5.3	20.6	4.5	girls > boys**

* $p < 0.05$
** $p < 0.01$
ns Not significant at 0.05 level

Table 2. Chemistry study : comparisons between boys and girls from single sex and co-educational schools

Test†	Gender in type of schools (means)				Significance one-way ANOVA)	Result of Scheffe ranges test
	Boys single sex (BSS)	Boys co-ed (BCE)	Girls single sex (GSS)	Girls co-ed (GCE)		
MS	35.9	41.1	37.6	42.0	**	GCE ≃ BCE > GSS > BSS
PS	21.9	19.8	21.8	22.9	**	GCE > BSS ≳ GSS > BCE
OS	7.8	7.7	7.8	8.7	**	GCE > GSS ≈ BSS ≳ BCE
LK	4.7	5.0	6.4	6.1	**	GSS ≳ GCE > BSS ≳ BCE
SOE	5.0	4.8	5.8	5.9	**	GSS ≳ GCE > BSS ≃ BCE
KA	10.6	9.6	11.6	10.4	**	GSS > BCE (others between)
SA	19.2	19.5	20.9	19.9	**	GSS > GCE ≳ BSS ≃ BCE

† For meanings of abbreviations see Table 1

** $p < 0.01$

Table 3. Physics study : Comparisons between boys and girls.

Test	Boys		Girls		Significant Differences
	mean	s.d.	mean	s.d.	
Manipulative skills (MS)	44.7	5.2	46.6	4.4	girls>boys**
Problem Solving (PS)	15.3	5.0	17.4	5.3	girls>boys**
Source of Evidence -Laboratory (SOE)	10.7	5.8	10.8	9.4	ns.
Knowledge Achievement (KA)	10.5	22.4	10.0	26.4	ns
Scientific Attitudes (SA)	22.7	6.3	22.6	9.1	ns

* $p < 0.05$
** $p < 0.01$
ns Not significant at 0.05 level

Table 4. Physics study : comparisons between boys and girls from single sex and co-educational schools

Test†	Gender in type of schools(means)				Significance (one-way ANOVA)	Result of Scheffe ranges test
	Boys single sex (BSS)	Boys co-ed (BCE)	Girls single sex GSS	Girls co-ed (GCE)		
MS	44.7	44.8	47.7	43.8	**	GSS> GCE≃BSS≃BCE
PS	15.1	15.7	17.8	16.6	**	GSS> GCE≃BSS≃ BCE
SOE	11.1	10.1	10.0	10.0	ns	
KA	10.1	10.6	11.3	5.8	ns	
SA	23.8	20.6	22.5	22.9	**	BSS> BCE (others between)

† For meanings of abbreviations see Table 3
** p 0.01
ns Not significant at 0.05 level

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Intervention method for motivating pupils (especially girls) to study the Building Trade

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"Rogozin" Comprehensive High School

1. Introduction

Representatives of the Departments of Labour and Education in Israel have recently declared that efforts should be made in order to encourage girls to enter the technical fields.

Thanks to modern production systems most of the work which in the past was done by men, may be carried out today by women too. Therefore girls should be encouraged to enter professions formerly considered masculine.

Increasing the percentage of girls who chose a technical trend for their schooling and their work, is a most complex task, because of the strong stereotypes associated with masculine and feminine crafts and because of the rooted norms concerning the woman's function in our society. The task is complicated also because of the many tactors involved in the vocational choice made by the girls themselves, their parents, teachers and advisers in the junior high school, in comprehensive high school, by employers and society in general (Epstein, 1976; Moore, 1984; Osipow, 1976).

One of my duties as being building coordinator trade, is to encourage suitable pupils to select my trade. The way I acted to encourage the pupils is informal and could be based on recommendation for other trades.

The formal education system in Israel includes kindergarten, elementary school (6 years), junior high school (3 years), high school (3 years) and advanced studies.

The selection of study level in junior high school programs and final examination in high school determines the chance of the pupil to develop his career in the future.

The programs in the comprehensive high school in which I acted are:

Academically oriented programs: Humanistic, Realistic, and Biologic.

Administration programs: Clerical, Secretarial, and Accountance.

Technical programs: Computer Systems, Electronics, Building and Mechanics.

Although the conception that counseling and selection should be based upon personal aptitude and achievements, in practice, achievements and stereotype influence the trade selection.

Based on research and personal experience I realised that most of the pupils, their parents and even the junior high school staff haven't the full information about each kind of technical trade, the possibility of advanced studies or work in the future for the pupils and especially for the girls.

Mostly girls don't believe in their mathematical and technical abilities, they prefer traditional task. Only a few girls dare to be pioneers and the minority in these fields (Becker, 1981; Carpenter, 1983).

The Building Program includes several kinds of trades which enable the pupil to continue various advanced studies or employments in the labour market such as the engineering office or the building sites. Among the courses: Building Systems, Building Materials, Statics, Architect, Construction Graphic and Perspective Drafts are included. These variaties enable both sexes joint advancement based upon personal inclination and qualification.

The possibilities of expected final examinations are: Full Matriculation (mathematics in medium level including plane geometry, or stereometry algebric and tregonometric) or partial matriculation.

2. Method of Intervention

The goal of the intervention is to increase the number of pupils in general and especially girls. We try to convince the pupils that a suitable pupil recommended by us will succeed in our program.

2.1 Convincing the School Principal

Discussions were held with the school principal to enable the reception of a larger number of pupils instead alternative programs, for instance: girls would be guided to administration programs. The explanation given to the school principal was based upon 3 factors: 1. This trade is for creative pupils who will enjoy crafts. 2. The cost of each pupil is lower than other programs. 3. The demand of the economic and national interest for increasing engineering and technical power by bringing more girls to this program instead of other programs.

2.2 After School Course for Junior High School

This course is in addition to the general studies and takes place in the afternoon by students, both boys and girls from the Technion (Israel Institute of Technology). A special project to advance technical manpower.

The curriculum of study included academic courses and workshops. Its aim was to get to know our program better and to help the pupil to decide his course of study when he has to select a program. The participants passed qualification examinations and at the end of the course the pupil got an evaluation. Therefore every graduate could be assured that our trade is for him. The course included both male and female students.

2.3 Information

2.1.1 Pupil information: We visited the pupils in junior high school before the school counselor started deciding with each pupil about his future in high school. The pupils were assembled for a lecture on our program, conditions for acceptance, contents and future development possibilities for both sexes.

Some boys and girls in our program took part in this meeting and the pupils of the junior high school could ask questions. In the program exhibition of the high school we show projects drafts and again give information that we indicated suitable for both sexes and suitable for our program.

2.3.2 Parents information: The parents of junior high school were invited to a meeting in the high school by the management to receive an explanation of the various possibilities for their children to continue their studies. They also visited the program exhibition. In addition we sent information pamphlets with the pupils to the parents who missed the meeting.

2.3.3 Counselors School Information: There was a separate meeting with every counselor. They received full information of the qualification required for our trade, level of achievements especially in mathematics. We paid a lot of attention to convincing the counselor of equal suitability of both sexes in our trade.

2.4 Qualification Examination

To prevent failure and drop out of pupils and to prevent a decrease in motivation to join our trade, we tested the applicants for depth vision and ability in drafting in addition to the grades in their diplom.

The fact that a qualification examination is required increase the prestige of our trade. The pupils who passed the examination felt that they would succeed in their choice of study. This examination is more important for the girls, who had not the same opportunity as the boys to know, what was expected in the draft crafts (only the boys had draft lessons in junior high school).

2.5 Computer Use

To the applicants for our trade we clarified what would be learned during the computer lessons. The pupils study computer language and the use of the computer in the building field. The clarification was supposed to attract the young generation and their parents who see in the use of computer proof of advanced technology. The use of computer diminish the fears of doing drafting by hand but depth vision is still required.

2.6 Information about Advanced Studies and Future Employment

During the studies in our trade, our teachers choose to visit some kinds of factories engineering offices and institutes of technology. By these visits boys and girls might improve the choice of their future career. We arranged a meeting between pupils and their parents and representatives of some technical institutes.

2.7 Trade Staff's Contribution

At the beginning, our teachers have a mission to change self conception and to strengthen then the girls who had no experience in drafts and technical subjects as the boys had. We adjust the educational systems to diminish the difference. After one semester the difference is no longer significant. The teachers pay attention to the stereotypic images of stable crafts and speak with their pupils about the possibilities of advancement. The teachers follow achievements of each pupil and parents get information about it. The teacher explained to the pupils and their parents again and again the importance of the final examinations (mainly mathematics) as the key for progressive study.

Results

Distribution of boys and girls by graduation years

Sex Graduation year	Boys No.	Girls No.	Total No.	Boys %	Girls %	Total %	Remarks
1986	10	5	15	66.7	33.3	100	Before the intervention
1987*	21	13	34	61.8	38.2	100	After the intervention
1988**	19	17	36	52.8	47.2	100	

* Expected graduation years, now 12th class.

** Expected graduation years, now 11th class.

Comparison between graduates of 1986 and 1987:

The total increase of graduates are 19: 8 girls, 11 boys.

The total percentage increase of graduates are in average 55.80%: girls by 61.53%, boys by 52.38%.

Comparison between graduates of 1986 and 1988:

The total increase of graduates are 21: 12 girls, 9 boys.

The total percentage increase of graduates are in average 59.89: girls by 70.59%, boys by 47.37%.

4. Discussion

The intervention caused increase of graduates number. The girls who selected our trade instead of nontechnical programs changed their conception and their occupational image. Without intervention they would never dare to try technic crafts. The self convincement of the girls, their parents; counselors brought the girls to believe in their technical abilities.

5. Recommendation

The intervention described here is informal. It depends on the motivation and ideas of the trade coordinator. There must be formal instructions for selection of trade in every junior high school, so selection will be based on achievements, self aptitude assessment and full information about the trade and not by sex. This system could be implemented in other trades as well.

In summary, only by encouraging students to choose technical studies (especially girls) can educators reach the goal of training a maximum number of students for technical professions. Otherwise the closed circle of women in stereotyped professions will continue and prevent women from becoming a useful and needed professional in the national economy.

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Sex-related Differences in Mathematics- A matter of Quantity or Quality?

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Summary

The present study explores sex-related differences in mathematics learning and its possible determinants. It uses routine mathematical tasks (computation, concepts comprehension, and story problems) as well as less routine measures of mathematics performance which require students to estimate the solution and/or the solution process of mathematical tasks. General intelligence, and several affective measures were used as the possible determinants of the observed differences. Data from a large evaluation study of educational performance performed in one small city in Israel were used. The sample was composed of 275 seventh graders from two junior-high schools: 139 boys and 136 girls. In addition to the use of a pencil-paper tests battery, in-depth interviews of about 30 boys and girls were conducted during the study. All the students of this study had similar instruction in mathematics in each year of elementary school.

While no significant sex difference in the general routine mathematical task was observed, a sex-specific trend in performance on estimation of computational and story problems was detected. Sex-related differences were also observed in the predictive model of mathematics achievement using intelligence and mathematics' perception measures as the predictors. The findings are discussed in terms of sex-differences in cognitive and affective readiness for the learning of mathematics. Girls' inferiority on estimation tasks is attributable to their lack of self-confidence, lack of motivation and a high level of learning helplessness which then reflects on their strong commitment to traditional and familiar learning experiences.

Introduction

In the past, it has been an accepted belief that males are invariably superior in mathematics achievement (Maccoby & Jacklin, 1974; Glennon & Callahan, 1968). Recent research, however, suggests that such sex-related differences are not as pervasive as had been believed. Mixed results seem to emerge in different studies, demonstrating that boys perform better in some studies and girls in others. Typically, girls are found to be more

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successful than boys in performing computations. Boys, on the other hand, are more successful in solving story problems (Armstrong, 1980; California Assessment Program, 1979; Fennema, 1977; Marshall, 1984) or in solving tasks of higher-level cognitive complexity (Marshall, 1984; Fennema & Carpenter, 1981).

This sex-differential pattern of success in mathematics suggests that boys and girls differ in mathematics achievement not so much in term of quantity but rather in terms of the specific abilities they acquire. Girls appear to have mastered the application of arithmetic lows and rules which are fairly automatically used. Boys, however, appear to have mastered different sets of rules, which are applicable in mathematical contexts requiring more flexibile use. These speculative generalizations, however, require further confirmation (Marshall,1984). This study is addressed to this need. It explores whether girls' and boys' differ in their ability to estimate the solution of two kinds of mathematical tasks: computational and story problems.

The use of these performance measurements reduces the significance of computational skill's while emphasizing the relational reasoning required in quantitative situations. Consequently, we expected a somewhat different pattern of differences between boys and girls to emerge, from that observed in previous reserch. Girls' and boys' performance in mathematics is also examined by conventional or routine performance measures (computation, concepts comprehension, and story problems). The study further explores whether sex-related differences in specific measurements of mathematical performance tend to be equally reflected for boys and girls of different levels of general intelligence.

In an attempt to explore the determinants or origin of these apparent sex-related differences in mathematics achievement, several attitudinal, cultural and cognitive factors are usually studied (Marshall,1984; Leder,1980; Fennema & Sherman,1977). The present study will also look into sex-related differences in the perception of mathematilcs -- especially in terms of the nature of their relationship to different measurements of mathematics achievement.

Seventh grade students were studied in order to eliminate one major source of sex-difference in mathematics achievement, which has to do with earlier experiences. All the students of this study had similar instruction in mathematics in each year of elementary school.

The study

Sample

The subjects were 275 seventh grade students from two middle schools in one small city in the center of Israel. The sample includes 139 boys and 136 girls. All students were tested at the end of the 1986 school year on all achievement measurements, as well as on the affective scales. Students were tested for general intelligence at the end of their elementary school (6th grade). A full set of measures including intelligence, is available for a sample of 97 boys and 111 girls.

Instruments

Achievement measurement

The mathematics achievement test was constructed in the context of a large evaluation study performed in the city. It includes 30 multiple choice test items: 17 items in the form of conventional or routine mathematical tasks: and 13 items testing the ability to estimate solutions of a given task. Examples of conventional and estimation items are given in Table I.

Table I: Sample Items

Item Type	Example
Computation	$2\frac{4}{5} + \frac{1}{3} + \frac{3}{10}$ 36000:100=
Concepts comprehension	Which is the smallest fraction? $\frac{1}{12}$ $\frac{1}{15}$ $\frac{1}{20}$ $\frac{1}{18}$ What is the value of the numeral 2 in the number :182.506?
Story problem	On sunday the temperature in Jerusalem was 5°C. On Monday the temperature declined by 8°C. What was the temperature on Monday?
Computational estimation	What is the approximate solution? $16\frac{3}{4} - 10\frac{1}{100}$
Story problem-estimation	A small 50-gram package of coffee costs 1050 shekels. A big 200-gram package of coffee costs 3820 shekels. Which package is worth buying and why? A blouse requires $\frac{4}{5}$ meters of cloth. Approximately how many blouses can be made from 36 meters of cloth?

Note: To conserve space, the multiple-choice alternatives are not reproduced here.

Affective measurement

An 11-item questionnaire was constructed to measure students perception of mathematics. Each item was in the form of a Likert scale with four-point scale value ranging from full agreement (4), to total disagreement (1).

Intelligence measure

A group intelligence test (MILTA) was used to assess general intelligence. The test is used nationwide for 4th-6th grade levels. Scoring was based on the national norms for 6th grade, with a mean score of 70 and a standard deviation of 10.

Results

Mathematics performence of Boys and Girls

Table II describes achievement mean scores on both global and specific achievement measurements for boys and girls. t tests were performed for each measurment to examine the statistical significance, along with our evaluation of the practical significance of the observed differences.

Table II: Means, standard deviations and t values for achievement of boys and girls.

Group	Measure	Conventional Tasks: Computation	Concept comprehension	Story problems	Overall measure	Estimation Tasks: Computation	Story problems	Overall measure
Boys (N=139)	$\bar{x}$ (S.D)	62.8 (30.7)	78.3 (19.1)	69.6 (25.5)	75.1 (20.2)	52.6 (25.6)	60.4 (26.6)	56.3 (22.0)
Girls (N=136)	$\bar{x}$ (S.D)	56.8 (30.9)	70.9 (20.8)	66.5 (28.9)	70.8 (21.7)	47.6 (25.3)	54.9 (24.9)	50.9 (21.9)
Differences		6.0	7.4	3.1	4.3	5.0	5.5	5.4
t value		1.60	3.06**	0.84	1.71	1.68	1.78**	2.01**

* p<.05
** p<.005

The results concerning sex-related differences in the two global measures of achievement (conventional types of items and estimation items), reveal relatively small differences between performance levels of boys and girls to the advantage of boys. Worth noting, however, are the large discrepancies in level between computational and estimation performance within each sex group. t tests for dependent samples performed for each sex group reveal significant differences (t=12.53 df=138 for boys, t=12.33 df=135 for girls). Boys and girls alike are much more competent in solving mathematical tasks which are similar to the ones they are accustomed to solving in school.

The apparent, though small, differences between the performance levels of girls and boys was further examined through the more specific measures of mathematical achievement. Within the routine tasks, significant differences are obtained when concept comprehension is measured, while on the less conventional items, significant sex-related differences were obtained in the testing on story problems. In both cases boys perform better on these tasks compared to girls. Further analysis was carried out in an attempt to get a better understanding of the nature of these differences. We have chosen selected groups of boys and girls who excelled on the conventional part of the test (answered **all** 17 items correctly) and compared their performance level on the estimation items. The results demonstrate that no differences exist between the two selected groups of boys and girls when estimating computations (mean scores are 72.2 and 71.3 for boys and girls, respectively). Yet, a large discrepancy in performance is revealed for estimation in story problems (mean scores are 89.7 for boys and 70.6 for girls). Boys significantly outperform girls on this particular achievement measure (t=2.52 p<.02).

The Relationship between intelligence and achievement

Three intelligence levels were created: below average (more than 1/2 S.D. below mean), average (between -1/2 S.D. and + 1/2 S.D.), and above average (more than 1/2 S.D above the mean). Performance levels of boys and girls were calculated on the conventional and the less-conventional measures for each intelligence group. The results are demonstrated in Table III.

Table III: Means and standard deviations for achievement measures by intelligence.

		Conventional Tasks			Estimation Tasks		
Group	Measure	Below average intelligence	Average intelligence	Above average intelligence	Below average intelligence	Average intelligence	Above average intelligence
Boys	$\bar{x}$	61.3	75.4	87.9	52.5	50.7	71.4
	(S.D)	(19.9)	(15.1)	(10.9)	(17.6)	(19.1)	(18.1)
Girls	$\bar{x}$	54.4	71.5	80.5	34.4	49.6	61.8
	(S.D)	(25.8)	(16.3)	(16.0)	(19.8)	(19.1)	(18.7)
Difference		6.9	3.9	7.4	18.1	1.1	9.6

It is apparent that almost no difference in achievement exists between boys and girls of average intelligence level. Yet, relatively large sex-related differences are apparent for the other two intelligence groups.

Boys' and Girls' Perception of Mathematics

In order to reveal whether sex-related differences exist in the perception of mathematics, a discriminant analysis was performed on all 11

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attitude scales. The discriminant function obtained ($\chi^2 = 45.07$ $p < .0001$; Wilks Lambda=0.82 and R=.42) differentiates significantly between boys and girls. The difference between the sexes is 0.94 standard deviation as reflected by the group centroids (0.45 for boys, -0.49 for girls). An examination of the standardized discriminant function coefficients reveals four perception scales that contribute to the maximal differences between the sexes: **Desire to succeed in mathematics** (.48); **Help needed in studying mathematics** (-.44); **Mathematics as a difficult subject** (.40); **Ability to successfully learn mathematics** (.39).

Interpretation of the standardized weights and their signs suggests that boys are characterized as having a high need to achieve in mathematics without the benefit of extra help, despite the fact that they do perceive mathematics as a particularly difficult subject. Girls, on the other hand, are characterized by their strong feelings of wanting help in studying mathematics, even though they neither perceive mathematics as difficult, nor do they express a strong desire to succeed in the subject. The results also reveal that while almost 80 per cent of the boys were classified correctly, less than 50 per cent of the girls were. These results suggest, therefore, that girls form a highly heterogenous (polar) group when we consider their view of mathematics as a discipline.

Achievement correlates for Boys and Girls

In order to examine whether differences exist between boys and girls in the predictive model of achievement, a regression analysis was carried out for each sex-group. The dependent variable being a general measure of achievement, students' intelligence and perception of mathematics serve as the predictors. The results of a stepwise regression analysis for the total achievement measurement are demonstrated in Table IV. The two regression models have similar predictive values for the general achievement measure. Each explains almost 40% of the variance in achievement. Yet, it is apparent from Table IV that girls' perception of mathematics has no differential contribution to girls' intelligence measure in predicting mathematics achievement -- when measured by the total test score. Furthermore, we found that for girls consistently lower simple correlation exists between the measurement of mathematics perception and the various measurements of achievement, compared to the respective ones for boys. This is particularly reflected in the low correlation coefficient between perception and routine measures of

Table 11: Regression analysis of total achievement by intelligence and perception of mathematics

Group	Variable	R	R	R^2 change	simple r
Boys	Intelligence*	.59	.34	.34	.59
	Math perception*	.63	.39	.05	.32
Girls	Intelligence*	.62	.38	.38	.62
	Math perception	.62	.38	.00	.11

* indicates significance level of F entrance into regression

achievement (for girls) which seems quite consistent for each specific measurement of the routine items (.09; .07; .07 for calculation, concepts and story problems). On the non-routine achievement measurements, the correlation coefficient between perception and computational estimation (.23) is similiar for boys and girls. Yet, for girls,no linear relationship seems to exist, between perception and achievement measure on problem estimation (.03)

Discussion and Implications

There were significant differences in seventh grade boys' and girls' performance on achievement measurements concerning comprehension of number concepts and estimation of problems' solutions. Boys tended to perform better than girls on each of these measures of achievement. Although the absolute values of the differences are small, the direction of the differences remains constant.

Based on the assumption that girls are more rule-oriented, more automatic in rule application and less flexible in approaching story problems, as cautiously suggested by Marshall (1984), we expected that when measuring the performance of estimating solutions, sex-related differences in computation, would be reduced while sex-related differences in solving story problems would increase. The results of the study confirm our expectations at least in terms of direction.

It seems that when required to solve simple word problems with the use of set of rules or familiar strategies, girls and boys are almost equally successful. However, as the nature of the problem changes, and so do the required solution structures and strategies, boys tend to outperform girls. These results are extremely explicit in view of the large differences revealed between boys and girls who excelled on the more routine measure of achievement. These results confirm the

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general findings suggesting that estimation requires greater understanding than mere calculation (Gibb, 1985). Estimation of a problem's solution requires **mindful** rather than **skillful** sets of behaviors.

Although we do not feel ready to identify the causes for girls' relative inferiority on this particular performance measurement, we can suggest a tentative explanation based upon a review of the literature, aided by the in-depth interviews conducted during this study. Girls' characteristic lack of readiness and motivation seems to be especially apparent when they are faced with unfamiliar mathematical tasks. In our interviews with girls, we observed that they were more willing either to give up a problem or to try and solve it as a routine computation more rapidly and decisively than boys. These sets of behaviors were strikingly consistent for girls of both high and low intelligence levels. It seems quite likely that through lack of self-confidence, high commitment to traditional and familiar learning experiences, lack of motivation, and a high level of learning helplessness, girls turn away from investing the necessary mental effort to solve non-routine estimation problems -- all of which then reflects on their performance level. These findings do not suggest that girls are essentially less mindful mathematically than boys. It does suggest, however, that girls' affective readiness to study and to succeed in mathematics is inappropriate, and consequently is a strong barrier to the fostering of potential mathematical capabilities in girls. Since the study of mathematics appears not to be sex-neutral, girls' readiness is quite likely a product of cultural conditions reflected in both "proscriptions and prescriptions" as suggested by Fennema and Sherman (1977).

Our findings regarding sex-related differences in the perception of mathematics and mathematics learning confirm other studies indicating that as early as 6th grade, girls tend to express less confidence than boys in their ability to grasp mathematics (Fennema & Sherman, 1978), and that their need to be successful in mathematics is much less strong than boys. However, there are indications in this study that girls, as a group, do not manifest a well-defined and consistent attitudinal pattern towards mathematics as do boys. In order to better understand these findings, not only, additional affective scales are required, but further studies are needed to explore variability among girls in terms of family background, socio-economic status and school and non-school-related experiences.

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Girls understanding of Science: A problem of Cognitive or Affective readiness?

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Summary

The present study explores the nature and origin of sex-related differences in science achievement. It examines sex differences in four subject areas, and in specific and general measures of science understanding. It also examines the characteristics of items representing maximal differentiation between girls and boys' achievement levels. Finally, it explores sex differences in the predictive model of science achievement. The study uses the ninth grade Israeli data from the International survey of science achievement carried out by the International Association for the Evaluation of Educational Achievements (IEA).

The findings of the study resemble the typical pattern demonstrated in national and international surveys of science achievements (Comber & Keeves, 1973; NAEP, 1978). Boys perform better than girls, particularly in the physical sciences. No achievement differences were detected for the general measure of science understanding or scientific literacy. This confirm the results of the British Columbia Science Assessment (Erickson & Erickson, 1984). The findings also demonstrate that the maximal differences in performance level between the sexes are attributable to items highly related to non-school experiences. The results also demonstrate sex-related differences in the predictive models of science achievement where science-related affective measures are used as the predictors. Specific classes of errors were found to be encountered more frequently by girls than boys.

The observed differences between boys and girls are discussed in terms of sex-differences in science-related experiences and training. Girls inferiority in science is attributable mainly to the typical feminine affective profile -- hesitant, dependent, anxious, unmotivated and help-searcher learner.

Introduction

The issue of girls' capacity for science has received welcome attention by researchers in science education. The cumulative evidence indicating that achievement levels of girls in the sciences is considerably lower than that of boys has stimulated further research into this phenomenon; including its patterns, determinants and origin. The present study addresses itself to this need. With very few exceptions, research evidence demonstrates that boys' performance in science achievement measurements exceeds girls' performance (Walberg, 1969; Comber & Keeves, 1973; NAEP, 1978; Fleming & Malone, 1983; Erickson & Erickson, 1984). However, these sex-related differences are not consistent across grade level. Although boys' scores were found to be higher than those of girls even at the youngest ages tested, these early differences are not substantial. They tend, however, to increase with age.

The present study aims to explore the nature and origin of apparent sex related differences in science achievement. It examines sex differences in typical achievement measurements, as well as in measures less frequently encountered in previous studies.

Research evidence concerning achievement correlates in science suggests that students' motivation, attitudes and perception of self and of the science classroom can help explain differences found in studies of science achievement (Napier & Riley, 1985; Talton & Simpson, 1986). Therefore, the prediction models of boys' and girls' achievements in science is examined, in this study, with the use of affective measures.

This study focuses on ninth grade students almost at the end of their middle school studies. It uses the Israeli data from the International survey of science achievement carried out during 1983-84 by the International Association for the Evaluation of Educational Achievements (IEA).

The Study

Sample

The data used to examine sex-related differences in science achievements and correlates are (taken) from the IEA Israeli study. A total number of 2175 ninth graders from 74 classrooms participated in the study. However, a complete set of data on achievement and affective measure are available for 1934 students, 1034 girls and 900 boys.

Instruments

The study makes use of the following selected tests and questionnaires from the overall battery of instruments applied in the IEA study for the 9th grade (Table I).

Table I: Description of Instruments, Measures and Sample Size

Instruments	code*	Sample Size	Achievement & attitudinal measures
Achievement-tests	2M 2Y 2Z	1934 882 891	(4) Subject areas: (3) Taxonomic goals: (1) Scientific Inquiry (2) Levels of learning Opportunity
Understanding the the Nature of Science	B/ASUM	1934	(1) Scientific literacy (content free)
Attitudes	ATT 2	797	(3) Importance, threat & attractiveness of science (1) Attitudes towards schools.
Perception of Science Instruction and Learning	(2/3)IDES	932	(3) Teacher &Instruction &Students Involvement (2) Learning Commitment & Difficulty
Science self-image	2STU	1934	(1) Self evaluation and motivation

* used in the International study

Results

Sex-Related Differences by Subject Area

The results are reported in terms of p values: the percentage of a total group or sub-group who answered an item or items correctly. Group differences are, therefore, the differences between the p values achieved by the groups concerned. Tests of significance have been provided for these differences. Yet, for instances of pedagogical significance, raw differences in p values are also reported and discussed.

The results concerning sex related differences by subject area are apparent for all four areas. (Table II). The difference in biology are relatively small while the differences are more substantial as one moves from earth sciences to chemistry and finally to physics. Boys outperform girls consistently for all four subject areas. Differences range from 4 to 12 percent, reflecting differences of less than 1/4 standard deviation in biology to more than 1/2 a standard deviation in physics. Our ω^2 estimate is that sex accounts for about 10% of the variance in the subject area of physics.

Table II Mean Scores (p) values, Differences (D) and t values between Boys and Girls by subject areas.

Subject Area	Girls (N=1034)		Boys (N=900)		D	t
	X̄	S.D.	X̄	S.D.		
Earth Sciences	68.2	19.8	74.3	19.9	6	6.72**
Biology	59.5	17.7	63.9	17.8	4	5.33**
Chemistry	54.4	22.7	61.3	23.9	7	6.20**
Physics	52.5	15.7	64.6	17.5	12	14.51**
Overall Subject Area	57.6	15.2	65.1	15.5	7.5	10.77*

When the data from these four areas are aggregated by learning opportunity a similar pattern emerges. Sex-related differences are apparent for those items which were highly emphasized in school ("High"), and even more so for items that were less emphasized ("Low") in classroom instruction (Table III).

Table III Mean Scores (p) values, Differences (D) and t values between boys and girls by Learning Opportunity, Taxonomic Goals and Science Understanding.

Measures	Girls (N=1024)		Boys (N=900)			
Learning Opportunity	X̄	S.D.	X̄	S.D.	Difference	t
High	63.5	17.4	70.6	16.9	7.1	9.07**
Low	47.6	18.7	58.2	19.9	10.6	11.92**
Goals Level						
Information (knowledge)	54.9	18.4	61.9	18.7	7.0	8.35**
Comprehension	60.0	15.9	67.9	15.5	7.9	9.24**
Application	57.5	16.8	65.1	17.2	7.6	9.72**
Science understanding						
Understanding of scientific processes	57.8	21.4	66.0	21.1	8.2	8.45**
General understanding the nature of science (scientific literacy)	58.3	23.2	58.4	24.0	-	N.S.

Sex-Related Differences by Goals

In the goal areas classified according to Bloom's taxonomy, the differences between the sexes are similar in questions designed to test information, comprehension of concepts and principles, and ability to apply knowledge. The differences of 7 to 7.9 percent to the advantage of boys reflect differences closer to 1/2 a standard deviation (Table III). A similar achievement pattern exists within each sex group. Mean scores

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are higher for items designed to test comprehension of concepts or principles, whereas scores are lowest for informative items.

The second dimension of goals in which sex-related differences are examined is concerned with understanding the nature of science and scientific inquiry. Here the results seem to show two different kinds of findings. First, in testing for the understanding of scientific processes which require reasoning in a scientific context, boys significantly out perform girls. However, when boys and girls are compared on their level of understanding the nature of science in general (scientific literacy), these differnces seem to disappear (Table IV).

Further examination of sex related differences in understanding scientific processes was carried out with the use of ANCOVA, where students' achievements on knowledge (information) items serves as a covariant. The achievement estimates of boys and girls in the measurement of understanding scientific processes reduced the differences between the sexs from 8.2 percent to 4.5 percent. (Expected mean scores of girls and boys respectively were 59.6 and 63.9.)

Sex-Related Differences by Discriminating Items

In order to examine the nature of the apparent sex differences, we applied a multivariate analysis on test items. Discriminant analysis was used to identify and characterize those items that reflect maximal differentiation between the sexes. Three separate discriminant analyses were carried out for each achievement test used. The results for all three tests (2M, 2Y,22) demonstrate significant descriminant functions. The maximal difference between the sexes is about 0.89 standard deviation. It is also clear from the analysis that boys advantage was typically large for most of the discriminating items (nine items in all three tests).

Content analysis of these items shows that the items are highly related to activities that are more frequently encountered by boys than girls (batteries in a flashlight, electric circuit, motions etc). The only two discriminanting items on which girls significantly outscored boys were concerned with the knowledge of the human body and the biochemical composition of food. Particularly interesting is the fact that most of the discriminating items were classified as having lower levels of learning opportunity.

Differences in Errors Made by Girls and Boys

Analysis concerning sex related differences in the type of errors made was carried out on a sample of 20 items only. This is due to the fact that the achievement tests used in the International study were not originally designed as a diagnostic test. Thus, a post-hoc analysis of each item and its four distractors was made in an attempt to characterize the nature of errors manifested by each distractor. Our hypothesis regarding the characteristics of an error was verified by interviews conducted on a small sample of boys and girls.

In order to examine how girls and boys differ when they are incorrect, we compared the proportion of boys and girls who actually made a particular mistake (the relative frequency of both sexes who chose a particular distractor), with its expected proportion, depending on how many boys and girls responded (right & wrong) to the item. Z values were then calculated for each item. Thus, only the samples of boys and girls who err on an individual distractor of an item were concerned in the analysis. Error analysis was used only for distracters that were chosen by at least 9-10% of the students (boys and girls together).

The results demonstrate no differences between the relative frequency of boys' and girls' incorrect choices, when the choice relies upon the use of **irrelevant rules or strategies** while solving science tasks. Girls and boys alike are affected by misguided rules such as "a linear or additive relationship exists between two components of a compound".

However, sex related differences seem to emerge in the other error categories. Girls are more likely than boys to be affected by **perceptual, graphical or key word cues** which exist in the question or the answers. Also, girls are more likely than boys to choose a distractor which describes **valid and related information** while **ignoring** the particular **question** raised.

In only one item it was possible to identify distractor that demonstrate an error caused by the erroneous interchange of two formal scientific concepts. This particular item inquire into the advantage of using a lever for raising a weight. Boys tend to choose significantly more than girls (61.8% and 39.2% respectively) the distractor "less energy is required"": whereas girls tend to choose significantly more than boys the distractor "it is quicker". (71.0 vs 39.0 respectively).

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Sex-related Differences in Achievement Correlates

The results are discussed separately for the two sub samples of this study. Multiple linear regressions were performed using stepwise procedures, the dependent variable being the total science achievement measurement and the independent variables being: science related self-image, perception of learning and instruction (first sample), or attitudes towards science and school (second sample). The results demonstrate sex related differences in the regression models obtained: both in its overall predictive strength and in the order of variables which entered into the predictive model. The regression models for boys (sample 1) accounted for about 20% of the variance in the general measure of science achievement (R=.45): whereas for girls only half of (10%) the variance was explained (R=.32). The highest correlate of achievement was students' self-image as a science learner for boys (.35) and girls (.21) alike. The students' perception of difficulty or help needed in science learning is also a relatively strong predictor of achievements. Yet, it was the second most important correlate for girls and the third for boys accounting for an additional 3.2% of the variance in achievement for each group.

A similiar pattern emerges from the regression models in the second sample. The predictive model of achievement, using attitude measurements for boys, accounts for twice the variance in achievement compared to the model for girls (R=.42 and R=.31 respectively). Also, the second strongest predictor of achievements for boys was their attitude towards the importance of science; whereas for girls it was their attitude towards school.

Discussion and Implications

The results of the study resemble the typical pattern demonstrated in national and international surveys of science achievements (Comber&Keeves, 1973; NAEP, 1978; Erickson&Erickson, 1984). Boys clearly perform better than girls, particularly in the physical sciences. In the biological sciences boys' advantage is less apparent and relatively small. In view of the large performance gap on items having a lower estimate of "opportunity to learn", as well as the stereotypical characteristics of the most discriminating items between boys and girls, we suggest that the observed differences are attributable to unequal science related experiences and training of boys and girls. Research on sex-related differences provides strong evidence regarding cultural stereotyping of female role and career orientation (Walberg,1967; Hockell & Lobonc,1981). It also attributes girls' inferiority in sciences to lower parental expectations and encouragements which manifest in a girl's daily life by a lack of stimulation and opportunity to explore scientific phenomena, at home, as well as at school (Kelly,1981; Kahle&Lakes,1983).

Although this pattern of girls' stereotyped socialization is believed to lead toward girls' lack of science understanding in specific content areas (Kahle & Lakes,1983), this study indicates that girls' underachievement in science does not reflect a basic deficiency in science understanding. We have noticed that no achievement differences were detected for the general measure of science understanding. Also, when the differences in knowledge of specific content areas were eliminated, the discrepancies for the specific measurement of understanding scientific processes were substantially reduced.

It seems therefore that girls' underachievement in science is not so much a matter of incompatibility, but rather a problem of **affective readiness**. Lack of self-confidence, lack of interest, and low aspiration are quite likely to be manifested by the limited time and mental effort invested by girls when faced with science tasks -- which, of course are then reflected in their levels of performance.

Although any interpretation regarding the characteristics of girls' errors must be limited and cautious, we feel that the results obtained support our contention. Girls' tendencies to be distracted by powerful cues or true but irrelevant facts, seem to reflect the "hesitant, dependent, anxious, unmotivated, help-searcher" learner of the typical feminine affective profile. However, error pattern analysis of boys and girls alike is in need of further examination. This seems to us to be a highly intriguing line of research, and even more, highly important.

The identification of variables predictive of science achievement has been a continous educational research effort for more than 50 years. The results of this study suggest that assessement of science achievement correlates needs to be applied separately for samples of boys and girls. It further suggests that even the use of sex as an independent variable (within a combined sample), when applied in a linear regression model, may obscure the results due to possible interaction effects between sex and other meaningful independent variables or affective correlates of achievements. This is reflected in this research by the sex-related differences observed even in the simple correlation coefficents. The results seem to suggest that we have not yet identified the most relevant affective measurement which may describe, explain and predict girls' performance in sciences.

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TREND IN ENROLMENT OF GIRLS IN MATHEMATIC, SCIENCE AND TECHNOLOGY IN KENYA PRIMARY AND SECONDARY SCHOOLS 1981-1985

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INTRODUCTION

Women and men have realized the significance of Mathematics, Science and Technology in everyday living and in the work world. In absence of such knowledge, one may not fully appreciate the resources available to derive a better quality of life, and one may limit choices of many meaningful careers. This is because the world has become more and more technologically oriented and therefore complicated for those not equipped for such changing and demanding ways of living.

Education gives one the knowledge and skill needed to cope with this new world. And therefore great care needs to be taken to make certain that a relevant curriculum is planned and implemented to the fullest benefit to the participants.

The government of Kenya has been aware of the disparity in education between boys and girls and purposeful plans to overcome these disparities have been under way since 1963. This is reflected in the percentage of the budget used on education. In 1982/83, 67% of the total expenditure in the social services was

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marked for education. According to the Economic Review 1983 the Kenya government has given priority to the following policies:

i) Encouraging viable interraction between schools and local communities, particularly through parents' association.
ii) Intergrating education with rural development through diversification of the curriculum emphasizing the teaching of practical skills that suit the pattern of employment opportunities.
iii) Promoting ethnic aspirations and social obligations to uphold traditional African values while preparing for the challenges of modern society.
iv) Minimizing school wastage by promoting student qualities of creativeness and innovativeness to guide school-leavers into productive employment.
v) Correcting the imbalances in secondary education that exist between districts between boys and girls and between people of different income groups." Economic Review 1983.

The policies stipulated above were implemented in 1985 when the Ministry of Education Science and Technology launced its 8:4:4 system, that is 8 years primary education, 4 years of secondary and 4 years of University. The curriculum is gender non discriminating in that males and females take the same courses from primary through secondary school. It is intended that the last part of 8:4:4 system namely the University education will show enrolment improvement as a result of improved primary and secondary science and technology education.

Primary Education

During the years 1961-85, enrollment rate for both boys and girls as figure 1 indicates, evens up. 45% of all pupils in primary schools during the last five years were girls. After the 8:4:4 system was effected in 1985, standard 8

TABLE 1: PRIMARY SCHOOLS: ENROLMENT AND PERCENTAGE DISTRIBUTION BY STANDARD AND SEX, 1981-85

CLASS	1981		1982		1983		1984		1985	
	ENROLMENT AND % DISTRIBUTION		ENROLMENT AND % DISTRIBUTION		ENROLMENT AND % DISTRIBUTION		ENROLMENT AND % DISTRIBUTION		ENROLMENT AND % DISTRIBUTION	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
Standard 1	436.2 51.7%	402.2 48.3%	467.8 51.5%	440.9 48.5%	460.6 51.8%	429.4 48.2%	447.2 51.7%	417.4 48.3%	436.5 51.4%	412.1 48.5%
Standard 2	362.8 51.5%	342.2 48.5%	359.8 51.8%	335.4 48.2%	367.7 51.7%	343.0 48.3%	366.1 51.8%	340.9 48.2%	363.1 51.8%	338.1 48.2%
Standard 3	325.1 51.9%	301.0 48.1%	334.6 51.1%	320.3 48.9%	340.3 51.4%	321.9 48.6%	339.3 51.5%	319.1 48.5%	332.5 51.5%	312.9 48.5%
Standard 4	267.8 51.9%	247.8 48.1%	300.0 51.8%	278.8 48.2%	315.8 51.1%	301.9 48.9%	316.8 50.7%	308.6 49.3%	314.9 50.7%	306.4 49.3%
Standard 5	239.0 51.8%	222.1 48.2%	250.1 51.5%	234.7 48.4%	267.7 51.5%	260.6 48.5%	282.5 50.7%	274.6 49.3%	283.5 50.6%	267.7 49.4%
Standard 6	239.1 51.9%	221.4 48.1%	255.1 52.0%	235.4 48.0%	272.2 52.3%	248.5 47.7%	267.2 51.9%	247.6 48.1%	260.9 51.4%	247.2 48.6%
Standard 7	208.5 50.6%	160.0 43.4%	210.7 56.7%	160.9 43.3%	216.0 56.1%	169.3 43.9%	250.2 55.2%	202.8 44.8%	242.5 53.0%	215.0 47.0%
Standard 8	-	-	-	-	-	-	-	-	201.0 55.8%	159.1 44.2%
TOTAL	2,078.5 52.2%	1,902.7 47.8%	2,178.1 52.5%	2,006.4 47.5%	2,249.3 52.0%	2,074.6 48.0%	2,269.3 51.8%	2,111.0 48.2%	2,434.9 51.8%	2,267.5 48.2%

Source: Education Statistics Unit: Ministry of Education, Science and Technology.

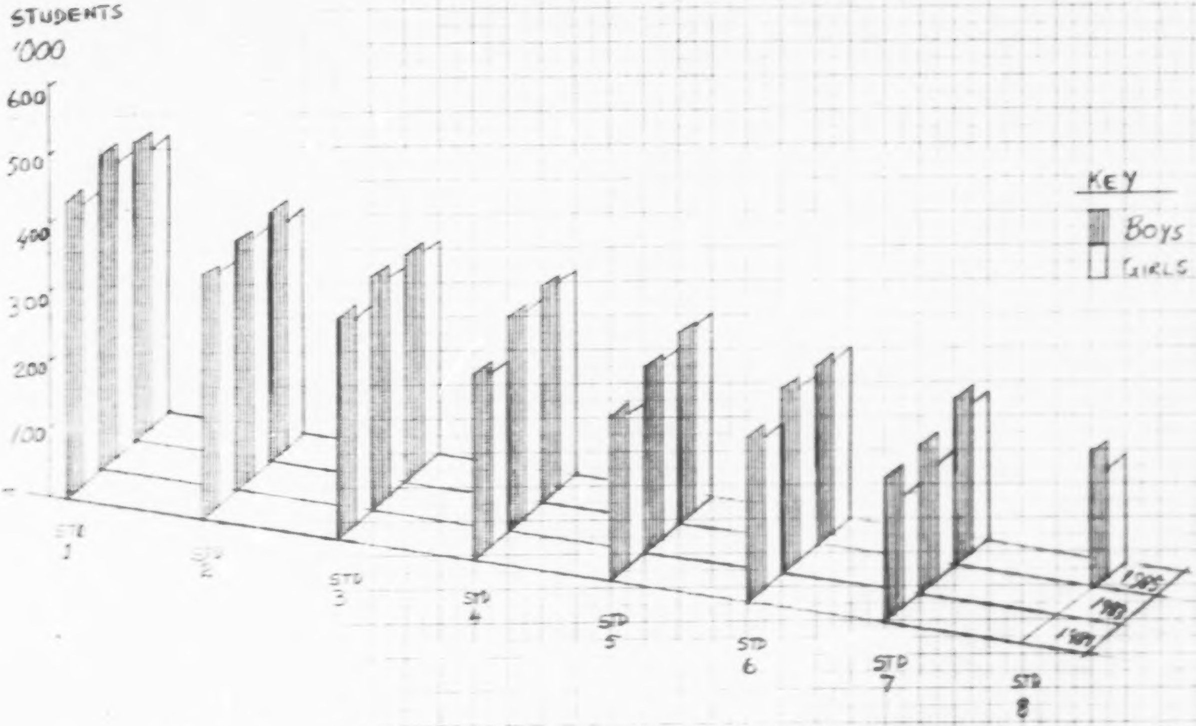

Fig 1 Primary Schools: Enrolment And Distribution By Standard, Sex And Year 1981-85

TABLE 2: SECONDARY SCHOOLS: ENROLMENT AND PERCENTAGE DISTRIBUTION BY FORM AND SEX, 1981-1985

FORM	1981		1982		1983		1984		1985	
	ENROLMENT AND % DISTRIBUTION		ENROLMENT AND % DISTRIBUTION		ENROLMENT AND % DISTRIBUTION		ENROLMENT AND % DISTRIBUTION		ENROLMENT AND % DISTRIBUTION	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Form 1	70,196 56.9%	53,364 43.1%	76,465 59.0%	53,137 41.0%	83,090 59.5%	56,524 40.5%	87,276 58.0%	63,076 42.0%	-	-
Form II	59.686 58.2%	42,876 41.8%	67.003 59.0%	46,561 41.0%	75,354 59.5%	51,262 40.5%	70,257 59.1%	48,704 40.9%	89,111 59.5%	60,651 40.5%
Form III	50,191 58.7	35,350 41.3	53,387 59.0%	37,099 41.0%	61,315 59.5%	41,711 40.5%	65,437 59.0	45,430 41.0%	81,010 60.5	52,792 39.5%
Form IV	48.405 61.9%	29,826 38.1%	50,594 59.0%	33,730 41.0%	60,266 59.5%	40,997 40.5%	61,949 58.9%	43,207 41.1%	72,909 62.8%	43,244 37.2%
Form V	7,733 69.1%	3,453 30,9%	6,878 64,7%	3,705 35,3%	6,876 59,5%	4,678 40,5%	8,776 64,7%	4,779 35.3%	13,502 69.5%	5,914 30.5%
Form VI	6,104 68.8%	2,766 31.2%	6,412 65.0	3,453 35.0	6,926 65.1	3,711 34.9%	7,748 65.0%	4,181 35.0%	13,501 74.7%	4,573 25.3%
TOTAL	242.315 59,1%	167.535 40.9%	260.739 59.5%	177,685 40.5%	293,827 59.6%	198,883 40.4%	301,443 59.0%	209,377 41.0%	270,033 61.8%	167,174 38.2%

Source; Education Statistics Unit Ministry of Education Science and Technology.

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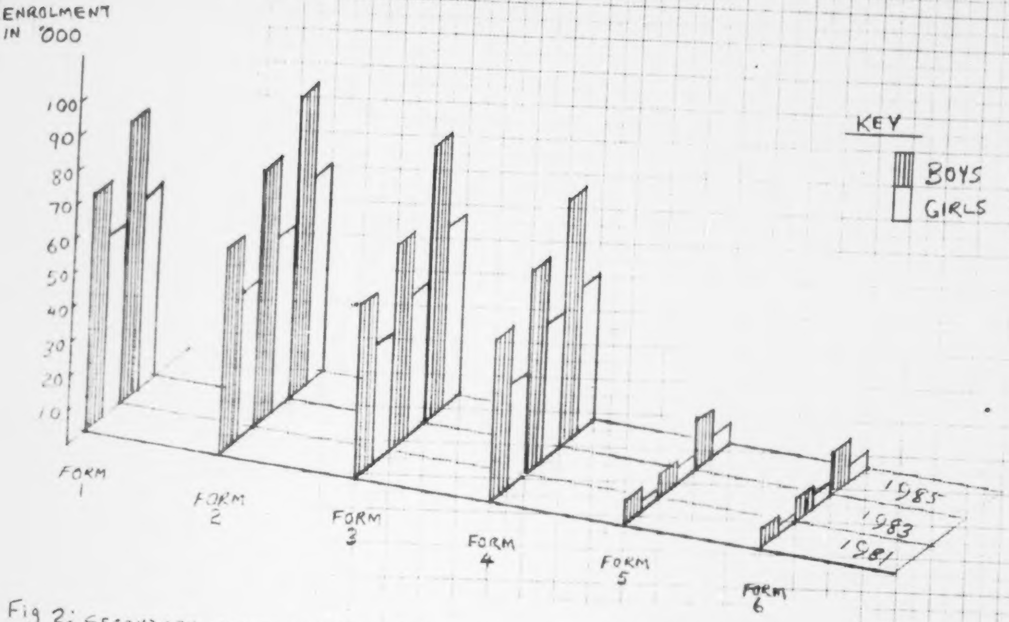

Fig 2: SECONDARY SCHOOLS ENROLMENT DISTRIBUTION BY FORM AND SEX AT TWO YEAR INTERVALS 1981-85

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in various scientific disciplines. In comprison to the enrollment in all the engineering courses. Womens enrollment in "Science" is quite impressive.

Mechanical engineering is an area very under represented by Kenyan girls. In 1981, no women were registered out of 734 students. In 1982, the first two women registered for this course and two others joined them in 1985. However only a total of 10 female students were registered among 949 mechanical engineering students.

Another area where girls are under represented is electrical engineering. Four girls among 560 students were registered in 1981. This number rose to 22 among 952 students in 1986. Building and civil engineering attracted 12 girls among the 504 enrolled in 1981. This number rose to 61 in 1984 but the number droped to 16 in 1985. In 1986, 769 men were enrolled in this course in comparison to 22 women.

In 1981, 79 women took science among a total of 581 students. The number used to 102 women among 424 men in 1986. "Science" is an area where women's enrollment was on the rise whereas mens enrollment was on the decrease.

Girls enrollment in an assortment of courses including media and mathematics in Kenyan Polytechnics was more impressive than in all other courses. It is not only the numbers but the ratios of girls to boys that has improved. Although only 2590 of the students in media and mathematics were girls in 1986, their actual numbers were almost double that of 1981.

Between 1963 and 1979, enrollment in secondary schools in Kenya had grown by 1100 percent. (MARANGU, 1985). Growth has been noted in both student numbers and schools. Although Kenya women have made great strides in education up to the secondary school level, they continue to lag behind in areas of engineering, science and mathematics in Kenyan Polytechnics. Ways and means must be sought to find out what keeps women out of these technical professions and assistance be given to those interested and capable of coping within these programmes.

The majority of the books used in Kenyan schools to teach Mathematics, Science and Technology are authored and published overseas. Perhaps locally written books might inspire girls to study these subjects if there is a greater emphasis on application to the local conditions. Cultural practices affect enrolment of girls in mathematics Science and technology need to be de-emphasized.

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Correlates of Female Interest in Science

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Eccles, Adler, and Meece (1984) developed a theory by which female interest in science could be conceptually outlined. Simpson (1984) applied this theory to the study of interest in science. However no empirical work has been done to investigate personal and demographic predictors of female interest in science. This study investigated the relationship between Myers-Briggs Type Indicator and the Rotter Internal-External Locus of Control Scale personality variables, self-reports of confidence in science preparation and ability, career and personal goals, recognition of the extent to which women face barriers in achieving career success, and perception of the extent to which a professional career would interfere with achieving satisfaction in having and raising a family.

Method

Data were gathered to answer these questions through administration of a questionnaire designed to identify relevant personality and demographic information on correlates of female interest in science.

Subjects

Subjects were 353 of 355 female first year students inventoried just prior to the beginning of classes and prior to the return of upper class students. Of those surveyed, 86 subjects expressed interest in pursuing a career in science. Of the 86 subjects expressing interest in science, 23 identified pre-professional programs in medicine, 11 identified biology, 4 identified chemistry, 3 identified engineering, 2 identified computer science, 2 identified math, and 2 identified physics as the major of choice. The remainder did not specify major interest.

Questionnaire

The questionnaire included the Rotter Internal-External Locus of Control Scale, the Myers-Briggs Personality Inventory, and selected personal and demographic items. The Rotter Internal-External Locus of Control Scale contains 29 items which predict the extent to which individuals locate control of their destiny in themselves see themselves as contrasted with substantially locating control for their destiny in external forces. The Myers-Briggs Personality Inventory (Briggs & McCaulley, 1985) defines eight variables which collectively describe the style one uses for seeking out information and making choices about what is important in the world. The variables are based on a system developed by Carl Jung (1971) for evaluating and labeling intellectual style. The variables identify preferences people exercise for focusing attention, collecting information, and making choices. The variables are conceptualized to operate in pairs. Everyone is seen to use all of the possible styles conceptualized, but every individual is seen to develop a unique pattern and a unique style. As a consequence, the individual is seen to systematically use one of the options in the pairs more than the other. The pairs are: extraversion and introversion; sensation and intuition, thinking and feeling; judging and perceiving. A brief description of the eight options in the four pairs can be found in Table 1.

Table 1
Myers-Briggs Variables

The person's interest flows mainly to

Extraversion --The outer world of actions, objects and persons. The extravert likes to do things, is interested in seeing the results of a job, in getting it done, and in seeing how other people do it.	Introversion --The inner world of concepts and ideas. The introvert likes quiet for concentration, tends to be careful with details, works well alone, protects uniqueness, demands integrity

Attention is focused on

Sensation -- The immediate, real, practical facts of experience and life. The sensate function values accuracy, is careful with details, works ahead, is realistic about the amount, of time a task will take, dislikes being rushed, works well with routine tasks.	Intuition --The possibilities relationships, and the meanings of experience. The intuitive function innovates, dislikes routine, works with a minimum of details, maximizes divergent thinking, dislikes being scheduled, conceives and implements new ideas, strategies, solutions.

Judgments or decisions are made by

Thinking: Objectively, impersonally, considering causes of events & where decisions may lead. The thinking function helps one defend choices.	Feeling: Subjectively, personally weighing the values of choices & how they matter to others.

Life is run by

Judging: Decisive, planned and ordered. One aims to regulate and control events.	Perception: Spontaneous, flexible. One aims to understand life and adapt to it.

The personal and demographic items used are reproduced in Table 2.

Table 2
Personal and Demographic Survey Items

Do you plan to take a (college) science major (Y N)?
Do you have sufficient mathematics and science ability to complete a (college) science major (Y N)?
Are you well enough prepared in math and science to handle a science major at Gustavus (Y N)?
How many high school semesters did you complete in Math; in Science (0 1-2 3-4 5-6 7+)?
How many college semesters do you plan to complete in mathematics; biology; chemistry; geology; physics (0 1 2 3 4+)?
What is the highest academic degree you plan to obtain (B.A. or B.S. M.A. or M.S. Ph.D., Ed.D., M.D., D.D.S., or D.V.M)?
How important is it for you to pursue your own career (Very important; Somewhat important; Not very important; Not important at all)?
Which statement best expresses your ideas about women and work (There are formal and informal barriers to woman obtaining desirable and/or highly paid work; There are no longer barriers to women obtaining desirable and/or highly paid work. Women just need to apply themselves and work hard.)?
Do you plan to marry (Y N)?
If you marry, what do you expect will be the income difference between you and your spouse (I will earn: substantially more; a little more; about the same; a little less; substantially less)?
How many children to you plan to have (0 1 2 3+)?
Do you believe that having a career would interfere with your being able to marry and have a family (Y N)?
Did your mother work between when you were born and when you started college (Y N)?
What do you realistically expect you will be doing at age 30 (Part-time work; Full-time work; Full time homemaking; Otner)?

Math and Verbal college entrance test scores were also obtained from college records for each subject.

Hypotheses

It was hypothesized that the Myers-Briggs variables introversion, intuition, thinking, and perceiving; and the

Rotter internal orientation would associate with, and increase interest in, science. It was hypothesized, also, that high school background in science, confidence in ability and preparation in science, increased exposure to high school science classes, increased willingness to enroll in college science courses, recognition that barriers exist to female professional achievement, belief that careers need not prevent one from having and enjoying a family, expectation of equal salary opportunities, valuing career, having had one's own mother work, and planning for full-time as contrasted with part-time work at age 30 would all be positively related to, and predictive of, interest in science. It was hypothesized, finally, on the basis of work done with successful scientists in each basic science group (Briggs & McCaulley, 1985) that Myers-Briggs sensation scores would associate with and predict interest in chemistry, that Myers-Briggs intuition scores would associate with and be predictive of interest in mathematics and physics, and that Myers-Briggs perception scores would associate with and be predictive of interest in chemistry and biology; and it was hypothesized that interest in medicine would distribute equally among all eight Myers-Briggs scores.

Criteria

Chi square associations were deemed statistically significant if $p < .01$ that the relationship observed could have occurred by chance. Yates corrected Chi Square was used for all 2 X 2 tables as the number of cases was greater than 21.

Results

The Myers-Briggs variables introversion (X^2=57.46, ldf;

p>.0001), intuition ($X2=62.20$, 1df; $p>.0001$), thinking ($X^2=9.64$, 1df; $p>.0001$), and perceiving ($X^2=66.09$, 1df; $p>.0001$) associated with interest in science. as hypothesized. The Rotter Internal score did not differentiate ($X2=.32$, 1df; $p>.5718$) between science interested and science not-interested subjects. It should be noted, however, that both science interested and science not-interested subjects achieved high internal scores.

Science interested subjects indicated increased confidence in their ability ($X^2=59.97$, 1df; $p>.0001$) and their high school preparation ($X^2=67.83$, 1df; $p>.0001$) in science.

High school background in mathematics did not, but high school background in science did, associate with science interest as expected. Both science interested and not interested students reported high levels of math preparation. The average student in each interest group completed seven of eight possible semesters of high school math. High school background in science associated ($X^2=33.83$, 2df; $p>.0001$) with interest in science. The average science interested student had seven or eight semesters of high school science whereas the average non-science interested person had five or six semesters of high school science.

Science interested subjects projected taking significantly more college science courses than did non-interested subjects. Significance values for each were: mathematics ($X2=22.30$, 4df; $p>.0001$); biology ($X2=172.08$, 4df; $p>.0001$); chemistry ($X^2=161.89$, 4df; $p>.0001$); and physics ($X^2=89.95$, 4df; $p>.0001$).

Science interested subjects were more likely to recognize that barriers exist to achievement ($X^2=55.14$, 1df; $p>.0001$), were more likely to recognize that career need not interfere with having and successfully caring for a family ($X^2=48.51$, ldf; p>.0001), and were more likely to indicate that they would marry (X2=9.13, ldf; p>.0002). Expectation of equal salary ($X^2=4.29$, 4df; p>.369), importance of pursuing own career ($X^2=1.67$, 2df; p>.4338), and expectations of being engaged in full-time over part-time work at age 30 ($X^2=11.37$, 4df; p>.4950) did not differentiate between the two groups.

The relationships found for mature scientists between Myers-Briggs variables and individual science majors held for the entering freshmen. Subjects interested in Chemistry showed a sensation preference. Subjects interested in mathematics and physics showed a preference for intuition. Perception scores associated with interest in chemistry and biology. Extraversion and introversion distributed evenly among the sciences and subjects interested in medicine showed approximately equal tendencies to hold any of the preferences. This suggests that, without coaching, college freshmen share important personality style characteristics with successful members of the sciences they hold as first choices. Significance tests were not calculated as the number of subjects in each science major group was small.

Math and verbal college entrance scores were significantly higher (math $X^2=79.67$, ldf; p>.0001) (verbal $X^2=79.05$ ldf; (p>.0001) at the 85th percentile break point for science interested over non-science interested subjects. Similar differences held in each of the individual science areas.

Discussion

The study demonstrated that certain personality qualities and certain qualities of confidence and ability to look realistically at the demands and rewards of science correlated positively with interest in science. Further work needs to be done on the relation of science ability and confidence. One might ask, for example, to what extent science interested subjects indicate more interest in science because they have greater confidence, and to what extent they do so because they have greater ability. Of particular relevance, in the context of this question, is the extent to which successful experience and can increase confidence and interest in moderate ability subjects. Much work, finally, is left to be done to identify the relation of Myers-Briggs variables to success in the individual sciences.

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A PILOT STUDY OF MALAYSIAN FORM FOUR GIRLS' AND BOYS' CONCEPTIONS ON ELECTRICITY

TAN BOON TEE

MALAYSIA

SYNOPSIS Empirical research findings in the last few years reveal an amazing fact that despite the innovations in science education to bring about more effective and meaningful learning of science, preconceptions held by students on physical phenomena greatly influence their understanding of science.

Girls tend to adopt a simplicitic view of natural phenomena more readily than boys. The purpose of this mini-pilot study is to investigate if there is a general tendency for girls to use a parsimonial model to interpret phenomena in electricity. Twenty-four Form Four (tenth year of schooling) girls and equal number of boys from the same form were randomly picked from a big rural school. These sixteen year old students were interviewed using the instrument prepared, tried out and reviewed earlier. The outcomes are quite revealing.

More in-depth research must be carried out on a much larger sample if any conclusive generalisations are to be made. The present study aims to help to show the direction of further probing.

INTRODUCTION There have been much interest generated in the last decade to study the concepts of physics held by girls and boys. Research findings support strongly the view that children at all ages hold their own opinions about a wide range of physical phenomena prior to their learning of science in school. These conceptual structures developed by children are based on their intuitions from interactions with environment. Such 'preconceptions' provide a sensible and coherent understanding of the physical world from the children's point of view.

Those 'preconceptions' dissonant with contemporary scientific frameworks are often labelled 'misconceptions'. Driver (1981) however, prefers to call them 'alternative frameworks' since these preconceptions are not freak pieces of knowledge but are parts of a well established framework that has been slowly developed through experience. Evidences suggest that these alternative frameworks may be very persistent and resist change by normal teaching methods (Viennot, 1979).

A number of investigations concerning preconceptions of electric current flow held by children were conducted (e.g. Osborne, 1982), using very simple circuits comprising a battery, a few connecting wires, a switch and a bulb. Others (e.g. Shipstone, 1984) extended the investigation to students up to 17 years of age and found that many of them still used pre-instructional model of their own well into the period of formal instruction. Shipstone's study deals with slightly more complex circuits including the use of fixed or variable resistors, and series and parallel connections.

Girls tend to adopt a simplicitic view of physical and natural phenomena more readily than boys. Their preconceptions and misconceptions of science principles seem to impede their interest in science and technology. This study, conducted using the method of structured interview, is a mini-pilot study to confirm the existence of preconceptions among boys and girls, and to determine if there is a general tendency for girls to use a parsimonial model in interpreting phenomena in electricity.

METHOD

The sample consisted of 24 boys and 24 girls randomly taken from Form Four science students of a rural coed school. These students had completed three years of integrated science course (year 7 to year 9 of schooling) and received about seven months of physics instruction at Form Four level. Their average age is 16.8 years.

To match the objective of the study, the interview questions were accordingly designed, tried out, reviewed and revised subsequently. Along with the questions, the necesarry apparatus set-up was prepared and tested.

RESULTS AND DISCUSSION

The original interview questions were in English. However, during the actual interviews, some of the questions where necessary were translated into Malay which is the medium of instruction in school. (The questions and responses are omitted in this presentation because of limited space.)

Based on the responses of the students, the following conjectures can be made:

- The students in the sample have a clear understanding that a complete circuit is necessary for current flow and that a bulb lights up as a result of electric current flowing through it.

- 10 out of 24 boys indicate that current flows through the cells, while practically all the girls (except 2) have the same correct concept. This seems to support the argument that girls tend to hold a simple wholistic view about circuitry.
- The students know the unidirectional flow of current through the circuit. None subscribes to the 'clashing current' model described by Osborne (1981) and Shipstone (1984).
- When one of the two cells of equal e.m.f. is reversed, the students could predict that no current flows. But their predictions are based on the idea of opposition of the poles. None explains it in terms of the e.m.f. of the cells.
- All the 24 boys and 18 out of 24 girls misconceive that electrons move 'very very fast' through the circuit when the switch is closed, because the bulb lights up immediately. This may be due to the fact that they were exposed to the 'water flow model' in their earlier years. 4 girls persist that current still flows when the switch is off.
- With regard to the conservation of electric current/electrons, 6 (25%) of the boys misconceive that electrons are 'used up'; 16 (66.7%) of them however maintain that current/electrons are conserved. As a comparison, Shipstone (1984) found that about 40% of the students studied held the 'unidirectional without conservation' model. Surprisingly 22 (91.7%) of the girls insist that

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the electrons are 'used up' (a parsimonial model). This is in stark contrast to the view held by the boys.

- A fused bulb represents a break in the circuit with no current/electron flow, say all the boys and 20 of the girls. 4 girls contend that electrons still continue to flow and 'spew out' at the broken ends of the filament much like a broken water pipe.
- When one end cell of three cells in series is reversed, all boys and girls remark that no current would flow because of the opposition of poles.
- When the centre cell of three cells in series is reversed, all girls and 22 boys still say that no current would flow, basing mainly again on their 'opposing poles model' despite the fact they were shown to be wrong in their prediction in the previous case. This appears to confirm that girls' and boys' ideas can be surprisingly tenacious to change even though practical observations contradict their earlier predictions.

IMPLICATIONS IN TEACHING

Although the study is not extensive and exhaustive with such a small sample (characteristic of the interview method), some implications in science teaching can still be gleaned from the results. In fact, studies have shown that children often modify, misinterpret or reject the 'scientific viewpoint' that is presented to them. They may regurgitate the taught facts in a test but it is not the way the child actually thinks about the world (Osborne, Bell and Gilbert, 1983). Teachers simply cannot ignore 'children's science', nor could they brush aside the 'differences' in the misconceptions held by boys and girls. They should modify science teaching to enable children to appreciate the differences between their present views and those accepted by science, and lead them to develop a personal perspective based on broader experiences. A few suggestions may be made for teachers to improve their students' learning of science. Teachers could:

- identify and be familiar with girls and boys views and use these views as the starting point in teaching. Through interviews, discussions or classroom questions students' concept and preconcept of certain physical phenomena can be elicited.
- provide learning experiences which challenge the views currently held by students. By making them aware of contradictions between their preconceptions and their observations, it is possible to influence them to accept the more appropriate scientific conceptions (Pines and Leith, 1981). The teacher therefore needs to develop an environment where students' views will be brought into the open, discussed and challenged in the light of alternative and more acceptable viewpoints.
- explain the differences in meaning between everyday language and specific terms in science, continually emphasising that words can have multiple meanings, identifying clearly which meaning is referred to in a particular context. In attempting to simplify, teacher must be cautious of words and analogies used, as students very frequently bring the everyday meaning of a word into the science class. For example, the use of the analogy of water flow to

explain current flow may have subtly brought about the misconception of current/electron flowing through a circuit in a 'very very fast' manner.

CONCLUDING REMARKS

This simple study demonstrates that children develop ideas about their own experience and give meanings to words to fit their views. They build their own theories to explain things happening around them and interpret through their own perspective. Girls are inclined to accept simpler explanations more readily than boys.

More in-depth and wider investigation should be conducted as a follow-up of this study in order to arrive at any conclusive generalisation.

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Is the Unpopularity of Chemistry Lessons with Girls Caused by the Unconscious Behaviour of Teachers?

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Investigations of the unpopularity of chemistry and physics lessons with pupils have been carried out by a number of researchers in the past years. Chemistry,together with physics, ranks rather low in popularity scales. Investigations reveal that chemistry lessons are even less popular with girls than with boys.

Although more girls than boys attend secondary schools, fewer girls are willing to go to the university. In our modern technological oriented world, however, a wide range of technical and scientific knowledge for both sexes is absolutely necessary. Highly paid positions are found in the scientific/ technical field; but many girls do not feel qualified or talented for them even today. Schools should therefore prepare girls and boys equally for their technical and professional life. Educational barries to girls must not be intensified, but should be removed, particularly by science lessons. Proceeding on the assumption that boys and girls are taught according to the same curriculum, it is necessary to investigate the reasons why girls disapprove of natural sciences and especially chemistry.

Are girls generally less gifted for chemistry (and physics) than boys, as Wilhelm Ostwald stated in his book 'Great Men' (1919): "Thus one purely impartially arrives at the conclusion that women in our time, independent of race and nationality, are not qualified for basic scientific work." He thinks the main reasons for this is the biological function of a woman. Since she is bound to bear children, there is no energy left to achieve great things in science. Friedrich Nietzsche (1844-1900) was even of the opinion that "if a woman is scientifically inclined, there is something wrong about her sexuality." Max Planck (1858-1947) agreed with this:"Amazones are also unnatural in the intellectual field." (Spiegel,1986)

Considering the historical development of women's academic careers in Germany it becomes evident that the biological function hardly is the reason for lacking scientific education of women. Women have only be allowed to go to the university since the beginning of this century. Lise Meitner, who started to cooperate with Otto Hahn in 1907, was only permitted to enter the building by a side-entrance, because she was a woman. She was not at all allowed to enter the lecture-hall, as women were not officially admitted to university studies in Berlin before 1908. Since 1920 women have been allowed to habilitate. The first habilitated woman in Germany, the mathematician Emmy Noether, was later granted an associate professorship without being permanently appointed (as a civil servant). 13 years later the National Socialist regime abolished the right of habilitation for women. There was even a direction that the share of women in students must not exceed 10%. This meant a disastrous setback for the development of academic careers of women. The restoration phase of Adenauer aera in the beginning of the Federal Republic of Germany rather resumed traditions of the German Empire than those of the Weimar Republic in the area of schools and universities. In 1954 there was not a single female professor, although academic equality of rights had formally been restored. Thus women have always been impeded in their scientific and professional development and kept from gaining influence on important social domains. Ostwald's opinion cited above still haunts people's minds, although emancipation has steadily progressed since then.

Nevertheless, the result of a lot of studies show a deficit of the girls today. It is necessary to interest girls in natural sciences. To achieve this, the reasons for the indifference and bad performance of girls in natural sciences must be found out. In principle we think that the unpopularity of scientific lessons with girls as well their lesser achievement are due to socialization. A sufficient number of women have proved their ability to optain outstanding results in natural sciences in spite of the enormous obstacles put in their way. Sex-differentiated practise take place not only in families, but also through social influences such as advertising, films, books, toys etc.

But is the role of the institution 'school' as well as the behaviour of teachers not important as well? A study by Dale Spender (1982) made evident that teachers in England favoured boys unconsciously. We propounded the hypothesis that this is also true for the Federal Republic of Germany, especially for chemistry lessons, and that teacher's behaviour is therefore one - maybe the decisive - reason for girls disapproval of chemistry lessons.

A number of empirical studies (Good,Sikes and Brophy <1973>; Spaulding <1967>; Frasch and Wagner <1982>, Spender <1982>) concerning lessons in general show that teachers pay more attention in a negative and positive sense to boys than to girls. Girls are frequently supported in their acquired passive behaviour, whereas boys are encouraged to be creative and to solve problems. Spear(1985) found that teachers are of the opinion that natural sciences are more important for boys than for girls. This attitude could already unconsciously cause a teacher to favour boys in particular situations during science lessons.

The aim of our study is to find out whether this behaviour of teachers can also be observed in chemistry lessons in the Federal Repuplic of Germany.

Lessons were observed at two secondary schools (one with urban and the other with rural catchment areas) over a period of time from the beginning of the school year in September 1985 until Christmas holidays. The classes were observed by two persons, one counting all contributions of pupils upon a question, the other classifying the questions according to the items fixed. Both observers were qualified to do this classification. Mutual controls of the observation results did not reveal any considerable differences.

Seven forms of the 8th grade (pupils age 13 -14) of secondary schools (196 pupils, 84 of them boys and 112 girls), which were taught by 6 teachers (5 of them men and 1 woman) took part in the investigation. In all, 80 lessons (23 of them double lessons) were observed. The subjects dealt with in the chemistry lessons were approximately the same in all classes. In both schools the same school-book - Grothe, Welt der Chemie - was used.

Results

Analysis of lessons observation for all classes and teachers yielded the following results:

Table 1: Analysis of observation for all classes and teachers

	112 Girls	84 Boys
Total	1.84	2.49
Encouragement to continue speaking	0.21 (11.4%)	0.29 (11.6%)
Praise related to subject	0.12 (6.5%)	0.20 (8.0%)
Reproof for lacking discipline	0.06	0.19
Spontaneous contribution	0.16	0.32
Simple question	1.10	1.32
Difficult problemsolving question	0.40	0.64

1. Boys are called upon significantly more frequently than girls by the teachers observed.
2. Boys are more often encouraged to go on speaking.
3. Boys are given praise more often than girls. Praise was only given in relation to the subject of the lesson, not for discipline and order.

Point 2 and 3 are, of course, dependent on the fact that girls are less frequently called up. Thus there are less possibilities for praise and encouragement. Reffering these two items to the total number of responses and calculating percentages, it appears that teachers encourage boys and girls almost equally (11.4% girls, 11.6% boys); however a higher percentage of boys' responses are praised (6.5% girls, 8.0% boys). In general very little praise was given with the exception of the one female teacher, who gave significantly more praise than her colleagues. She called on girls less frequently than boys, but she gave girls considerably more praise in relation to the total number of calls (19.0% girls, 13.7% boys).

4. The majority of the teachers disciplined boys more frequently than girls. In all, boys were reproved three times more than girls. Pupils were never reproved regarding the subject of the lesson.
5. On everage the boys expressed themselves spontaneously twice as often as girls. Thus their shyness for free speech seems to be distinctly lower than that of girls.

Conclusions

The results of our observation show quite distinctly that teachers pay more attention to boys than to girls in chemistry lessons.

Boys are more frequently called upon, are therefore given more praises and are more often encouraged to go on speaking than girls are. Due to this fact girls are certainly not motivated and stimulated to participate in chemistry lessons more intensively. Boys are reproved more frequently and thus are paid more attention to by the teacher than girls are. Boys often contribute spontaneously to a subject.

Boys have decisive advantage of girls due to their socialization. Girls have hardly got in touch with technical toys before attending science lessons, so that they cannot gain much experience in the technical/scientific area. Many boys possess a chemistry set before the first chemistry lessons. Contrary to girls, they are already familiar with chemical expressions when attending their first chemistry lesson.

Our working group tested 13 and 15 years old pupils of different schools for their knowledge of chemical substances and found out that boys have a much better knowledge of substances than girls (Müller + Ritterhof, 1984). Thus boys have an advantage over girls in chemistry lessons due to their experiences. Due to their socialization and their - mostly little and initial - advantage in knowledge boys have the impression to be more effective in natural sciences than girls. Our results show that school corroborates this impression.

With another test we want to ask boys and girls at the age of 12(before attending their first chemistry lesson) and at the age of 15-16 (after three years chemistry lessons). With the test we want to find out:

1. How is their attitude towards chemistry lessons?
2. How is their attitude towards the chemistry industry?
3. Do the pupils notice sex-differentiated practice in their life? How is their attitude towards this?
4. How do boys and girls at the age of 15-16 themselves explain their failure or success in chemistry; by gift, lacking diligence, good luck or bad luck.

Other investigations (Schuch/Hofmann, 1979) already showed that women and also girls at an age of 10 to 12 state lacking gift as a reason for failures and good luck or effort for success, whereas men explain failures by bad luck or lacking efforts and success by gift and ability. This result makes clear how difficult it is to motivate girls of advanced age for a certain subject, when they have the feeling that they are not sufficiently talented for it. For the basic attitude determines success or failure.

An important aim of our study is to inform teachers about these problems in order to avoid intensification of both direct advantage (knowledge) and indirect advantage (attitude) of the boys and to help girls make up for the lack. Every teacher who wants to further boys and girls equally will certainly be prepared to act accordingly during the lessons. This would mean to intensify girls' participate in the lessons and to motivate them for chemistry. Girls must be given the impression that their views also matter in chemistry lessons and are not neglected. Girls must be helped to drop their uncertainty.

A study of Harding (1983) shows that girls are especially interested in social issues in science lessons. They are searching a meaning of certain phenomena, they are rather interested in practical work and appear to set higher value on products than boys do.

Our questionnaire proves, however, that pupils of both sexes are very interested in practical work. The subjects dealt with in the 8th grade did in no way refer to social aspects. If it is true that girls are more interested in social aspects of science lessons, it should be considered, how they could be integrated into chemistry lessons and how they could be taught with a big share of practical, i.e. experimental work. It would certainly not be only the girls who profited by this, but also the boys as well as the chemistry lessons in themselves.

Teachers should try to polish up the image of chemistry and physic lessons. Lessons should make girls and boys realize that knowledge of natural sciences is very important in our modern technical world. Especially in the initial lessons girls must be informed about the views of science education - not only for their future choice of a profession - so that they can understand the concret purpose of science lessons. This is the only way to rouse their interest. Lessons have to go on from everyday experiences of pupils. Moreover the girls need scientific role models, so that girls may also identify themselves with it. Not the first female astronaut, but quite 'normal' female scientists should be presented as examples.

Besides the historical development of chemistry, girls and boys should also come to know the development of the female role in natural sciences. As mentioned above, women have only been allowed to study since the beginning of the 20th century. This would certainly explain to boys and girls that women could only play a minor puplic role. Achievements of women were kept secret by the patriarchal society.

It is important for pupils to comprehend the development of emancipation in natural sciences. Teachers, universities and seminars should combine to solve the problems, so that chemistry lessons at school will become more attractive and realistic, so that existing role conceptions will be removed and more girls will realized the use of learning scientific facts.

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FEMINIST CRITIQUES OF SCIENCE : IMPLICATIONS FOR TEACHER EDUCATION

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> "Australia is richly endowed, but our growth depends on the talents and energy of our workforce, which in turn depend on the quality of our education systems. We cannot afford to deny girls the chance for better choices. We all have a vested interest in improving girls' engagement in science, business, engineering and technology." Senator Susan Ryan, Minister for Education, July 1986.

> "The ideology of science, proclaiming its objectivity, freedom from values, and dispassionate pursuit of truth, has excluded women and been integral to their cultural domination, has harmed women's bodies .... and threatens the environment itself." Hilary Rose (1986, 58)

Is the choice for science and technology for girls unequivocally a "better" choice? Do we really *all* have a "vested interest" in increasing their participation in these areas? Do we want girls and women, who have so far resisted such recruitment, to become instead competent and confident participants in what many feminists see as "part of a culture of death"? How do those of us who are educators and feminists resolve the tension between these two statements: on the one hand on grounds of equity and utility the demand to increase the participation of girls and women in science and technology; on the other a consciousness that modern science increasingly threatens human survival?

In this paper I will look at questions raised by feminist critiques of science and the implications of these for education, in particular the education of teachers.(1) I will argue that these questions enable future teachers to develop a more coherent and justifiable personal philosophy of educational practice, one which takes seriously the need for public accountability and yet enables them to be "*in* the system", but *not of* it, if that is their wish.' (Woolf, 1938)

I will assume that in education, whether in schools or teacher education, the primary questions are *ethical* questions, because education relates, by definition, to *human well being*. What we believe schools ought to do and to be reflects our views of a good society, of desirable forms of human life and other beliefs and assumptions about humans, the social and natural world, knowledge and ethics. (Arguments concerned with the teaching of science and technology, that link schooling primarily to "economic needs" require careful scrutiny and justification in more fundamental terms.) (Commonwealth Schools Commission, 1986)

"Good" teacher education necessarily implies enabling future teachers to think about and justify what they will be doing as teachers in terms of fundamental beliefs about humans, society, nature, knowledge and ethics. This is essential if they are to be autonomous in the sense of being able to take responsibility for their actions as teachers.

Feminist critiques of science: Sandra Harding (1985) identifies five areas of feminist research which have increasingly demonstrated "science's deep and complex involvement in advancing an androcentric culture".

* Equity studies which have documented massive historical resistance to women's attainment of education, credentials and jobs and the social and psychological mechanisms which maintain discrimination.
* Studies of the uses and abuses of biology, the social sciences and their technologies which have revealed the ways science is used to serve sexist, racist, homophobic and classist interests.
* Critiques of biology and the social sciences which shatter claims to value-neutrality in "scientific method", and in which male bias in selection and definition of problems, and in design and interpretation of research, have raised questions as to the possible existence of any pure, or objective science.
* Studies of the gender symbolism in the purportedly value-neutral claims and practices of science in which rigid dichotomies: objectivity - subjectivity, rationality - emotionality, mind - body, masculinity - femininity are linked with the claim that human progress requires the domination of the latter by the former in each.
* A series of epistemological enquiries: feminist empiricism which leaves unchallenged the existing methodological norms of science; the feminist standpoint which claims that women's subjugated position provides the possibility of more complete and less perverse understandings of nature and social life; "the universal features of women's experience as understood from the perspective of feminism"; feminist postmodernism which challenges the assumptions on which feminist empiricism and the feminist standpoint are based.

The first three kinds of criticism, she argues, ask how women can be treated more equitably within and by the scientific enterprise, still conceptualizing it as redeemable or reformable. The last two ask "how a science apparently so deeply involved in distinctly masculine projects can possibly be used for emancipatory ends", (p. 29). Fee is one who argues for a "successor science":

> "one in which no rigid boundary separates the subject of knowledge (the knower) and the natural object of that knowledge; where the subject/object split is not used to legitimize the domination of nature; where nature itself is conceptualized as active rather than passive, a dynamic and complex totality requiring human cooperation and understanding rather than a dead mechanism, requiring only manipulation and control." (1986)

How then do these different feminist approaches help to clarify understandings of what it is to be human; assumptions about knowledge, nature, society and ethics, and the complex interactions between them? I will focus on three areas: the importance for teachers of political literacy, of empowerment and of epistemological shrewdness.

1. Political Literacy: understanding the link between science, technology and society.

Politicians, bureaucrats and educators are asserting that scientific and technological literacy are necessary for political competence, but even more important is an understanding of political and economic structures and of the role of science and scientists in relation to them. If our teachers are to be politically literate and effective political educators, teacher education programs must include a study from a variety of ideological perspectives, of the economic, political and social structures, nationally and internationally, of decision-making in science and technology which enables teachers to answer such questions as: Who establishes priorities for research and development?(2) How participatory and accountable are such bodies? How can we account for the division of labour on gender (class and ethnic) lines in scientific power structures? Feminist analyses enable us: to demystify the claim that pure science is amoral and apolitical, (Fee, 1982); to see the deep involvement of scientists, almost entirely male and white, with dominant political and economic structures, with the military-industrial complex,(3) with environmental destruction; to see the hierarchical assumptions about the control and dispensability of humans and nature which underpin such activities (Keller, 1985; Merchant, 1980); to demand, for all scientific research, ethical frameworks which relate to common welfare, both national and global.

2. Empowerment: a sense of one's own power to interact creatively with others and with the natural world: clarifying our concept of what is to be human.

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Two crucial beliefs for teachers to hold about their students, as about themselves if they want to maximize learning, are a belief in their own intrinsic value as persons and a belief in their capacity to learn. How does feminist research illuminate such questions as: Are differences in ability/achievement in mathematics, science, athletics, art, in caring for others, biologically determined, socially constructed, self-determined?

* Demystifying biological determinism. Determinist theories have been used by power elites to support sexist, (racist and classist) ideologies and to explain and justify the differential educational experience of girls. Such theories, when internalized, e.g. by girls, limit their sense of their own value and abilities as persons and hence their power to achieve and act across the whole range of human potentialities. Feminist analyses (Bleier, 1986) have been crucial in demystifying theories of biological determinism exposing the inadequacy of such research even when assessed according to its own validation criteria.

* Theories about the construction of gender and of science. Evelyn Fox Keller's work, based on object-relations theory, shows how the characterization of science as masculine, objectivist, autonomous of psychological, social and political forces, encourages the self-selection of persons, both males and females, who fear loss of cognitive and affective autonomy and who are attracted by a way of knowing which is seen as offering authoritative knowledge, separation and control. Keller (1985) argues that a gender-free, humane, non-destructive science will require, as does the capacity to love: a separation between the knower and the known, but one which facilitates a caring knowing interaction with the other.

* Valuing women's traditional praxis: the caring labour of women. Feminist scholarship enables us to reclaim and rename the traditional caring labour of women and to see in it "prefigurative forms of a new society". Rose (1986) argues that reflection on such labour can enable women to develop a critical consciousness of the economic, political and social power structures that exploit and control their private and public lives, and an awareness of the central importance of the public and private caring labour of women with its double-sidedness "as labour and as love".

* Reclaiming alternative concepts of what it is to be human. Feminist historians working from an ecological perspective have shown how images of women and nature have changed during the past 200 years which have

seen the rise of industrial capitalism and modern science (Merchant, 1980). As the cosmos ceased to be seen as living and interactive, becoming instead a "dead" machine, controllable and exploitable by humans, in the name of "progress", so humans, or rather women and other oppressed groups, came to be seen as manipulable objects, their behaviour able to be explained, controlled and exploited in terms of linear, reductionist, mechanistic theories, based on false, genderized dichotomies. From this perspective education is reduced to skill training, the skills to be acquired being predetermined by the economic "needs" of the society. Learning is the shaping of behaviour controlled from outside by the teacher, a form of operant conditioning. Questions of ethics and politics are neutralized. Education is a technical not an ethical matter.

The ethical concept of person implicit in feminist epistemologies, affirms the priority of human consciousness, and emphasizes "holism, harmony and complexity rather than reduction, domination and linearity" (Rose, 1986). Above all it shows the importance of ethical questions for teachers.

3. The acquiring of wisdom: the ability not to be manipulated by experts, to deconstruct and reconstruct knowledge and practice in relation to one's own value system or worldview, i.e.

* Deconstruction. Feminist critiques have demonstrated that science's claim to be objective, dispassionate, value-neutral and hence authoritative and progressive, can be challenged as mystifying of science's methodology, epistemology, its relation to society, and its implicit assumptions about human nature. (Fee,1983) Scientific knowledge is not culture or context free, independent of who generates it and for what purpose. In all scientific inquiry the beliefs and values of the researchers, in particular beliefs about humans, society, nature and knowledge, enter into every aspect of the construction of the research, both the selection and conceptualization of the problem, and the design and interpretation of the research program.

Teachers must be able to DECONSTRUCT, or critically examine for underpinning assumptions, all theoretical knowledge and educational practice,both what and how they will teach. For example: Where did this knowledge come from? What was the purpose of the research? Funding? In whose interests does such knowledge operate? What views of humans/nature/society/knowledge are implicit? Are people seen in terms of gender (class, ethnicity)? Who/what is left out, or differentially treated? How do I know what is claimed to be true is

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true? What evidence/argument supports it? Are limitations explicit in the conclusions, etc. etc.

* Reconstruction. Teachers must also be able to reconstruct knowledge, so that both they and their students are empowered rather than depowered by it. This knowledge, or naming, then must be continuous with their experience, embodying their values, enabling them to see the world in a way that makes their own understanding of it, and action in it, possible and worthwhile, indeed possible because it is seen as worthwhile.

For women and girls it will involve construction or selection of knowledge that transcends science's gendered dichotomies: Knowledge gained through senses other than sight, or through intuitive responding to people and nature, through healing through the loving "laying on of hands". Can we construct knowledge that acknowledges the complex interaction between the knower and the known; that identifies and affirms the ethical dimensions of the construction of knowledge and the responsibility of the knowledge creators for the knowledge that they create; that engenders excitement and enthusiasm about what is being acquired and about the action that can follow from it in terms of human and natural well-being? It is within such parameters as these that scientific knowledge and technological skill must be reconstructed if we want girls and women to participate fully and significantly i.e. if we want them to be able to act and to see themselves as able to act.

Many feminists, of course, believe that a science that transcends such dichotomies is not possible except in a society in which present class and gender hierarchies no longer exist, (and many question that possibility as well). The question is, can we enable women and girls through the teaching of science, reconstructed in these terms, to be sufficiently empowered to be able to work within, or on the edges of, dominant science and technology and be able to act to transform it, if this is what they wish to do? This, I believe, will be possible only if, as well as coming to understand how science works, they come to understand what science is and how it functions within political and economic power structures, and so acquire the power and the commitment to act, together with others, to change it.

In the context then, of great pressure on teachers to encourage girls and women to study more science I have been arguing for a reconstruction of the teacher education curriculum in order to enable student teachers to critically evaluate their possible responses to this pressure.

There is a further point: sound practice must embody sound theory.

Such theoretical and intuitive understandings are necessary to enable teachers to understand why recent changes in classroom arrangements viz. single sex classes, relating science more to girls' experience and values, eliminating sexual harassment, etc., have improved girls' achievement in the sciences. Unless teachers develop such theoretical frameworks for critical analysis of dominant scientific ideology, when we teach teachers these practices for improving female performance in science, we could be reinforcing, by default, the dehumanizing practices of dominant science, i.e. communicating notions that human beings are manipulable, able to be understood in terms of isolated fragments of behaviour etc. Unless such practices embody sound theory, teacher education, as schooling, will be in danger of being reduced to a technology, to skill training. It will be "domestication", not "liberation" (Freire, 1973).

Similarly, teachers will be enabling, by such manipulation, more girls and women to acquire technological skills which, unless there is simultaneously a restructuring of the workforce and a redirection of technological development, they will be 'forced' to use in available jobs, not having acquired a commensurate level of political competency to demand more humane employment. We will have enabled them to overcome their intuitive rejection of dehumanising science in order to become in Rose's words, an (active) "part of the culture of death".

Feminist critiques of science, then, force us to think more critically and creatively about our responsibilities as teachers and teacher educators in enabling women and girls to make real choices about the kinds of sciences and technologies in which they are to become involved. As Robin Burns (1987) vividly reminds us:

> Science is intimately tied to the whole military-industrial complex that is dedicated to preserving its own powerful position, politically, economically, socially, culturally and ethically. Unless steps are taken to recognise these dangers, to examine the value basis of science and to critically question its normative role, and to ensure that the formal education system educates the moral as well as the intellectual capacities of the human being, the scientific dream for a better world could well become not merely a nightmare but the end of human survival.

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Notes

1. In this paper I will focus on implications for women student teachers since they make up the majority of such students, and because I am involved in a project researching ways of "changing the attitudes" of women primary and early childhood teachers-to-be to science.

2. Why, e.g., did Australian Nat. Health & Med. Research Council allocate A$1,800,000 to New Reproductive Tech. research cf. A$270,000 to breast cancer research? One in 15 Australian women get breast cancer, 2000 die each year.

3. 40% of world's R & D budget, and more than 3 million scientists and engineers are involved with the military. Canberra Times 13 Feb. 1987.

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New Wine and Old Bottles?

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Introduction

In Britain, economic and technological changes have been followed both by high levels of youth unemployment and a shortage of skilled personnel in a number of technological areas. Government response has been to introduce new education and training programmes. These include the Youth Training Scheme (YTS) (now a two-year, industry-based course for 16-18 year olds), the Technical and Vocational Educational Initiative (TVEI) (a four year, full-time school/college-based course for 14-18 year olds) and a Certificate of Pre-Vocational Education (CPVE) (a one year, full time education course for 16-17 year olds).

Additionally girls and women have been regarded as a resource from which to recruit for shortage areas. One manifestation of this was the designation of 1984 as Women into Science and Engineering Year (WISE 84) by the Engineering Council and the Equal Opportunities Commission.

A voluntary body - the Fawcett Society (which has campaigned for equality between the sexes since 1866) - has attempted to monitor how successful these new schemes have been in breaking down sex-stereotyped patterns of education and employment for girls and young women.

This paper reports on two such initiatives: a study of the involvement of girls in the first year of the YTS, and an Awards for Positive Action scheme which set out to identify and publicize examples of good practice by schools, colleges and training bodies, which have enabled girls and young women in the 14-19 age range to be more readily involved in areas of education and training usually dominated by males.

The Process of Change

In the 1970s I was involved in a curriculum diffusion study which enquired into the process of curricular change, using as a basis for the study the Nuffield Science Teaching Project. Within this project a number of science curricula, at various levels, were developed, trialled and disseminated. The study was confined to England and Wales where there were no official requirements for local education authorities, or their schools, to adopt the new curricula. In general, decisions to use, or not to use,

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the Nuffield courses were made by science teachers, usually with some degree of responsibility in their schools.

A model was developed to represent the process of decision-making (Harding, 1979). As teachers became aware of the Project and its materials, it seemed that they matched it and its demands against aspects of their own situation, asking what amounted to four simple questions shown in table 1. The outcomes of this matching process (the answers to the questions) placed teachers somewhere along each of the four dimensions (representing continua from low to high) of DISSATISFACTION, ACCEPTABILITY, RELEVANCE and FEASIBILITY. These are important elements in the process of change, for they represent the state of the potential adopter with respect to the proposed change. The teacher emerging from the matching process with a high level on each dimension was likely to use appropriate Nuffield materials, but a low on any dimension could block such use.

Table 1. Elements of decision making when faced with change.

Matching question	Outcome dimension
	low ---------- high
Do I need it? (Am I satisfied?)	Dissatisfaction
Do I like it?	Acceptability
Do my students (trainees) need it?	Relevance
Can I do it?	Feasibility

What has this to do with changing sex-stereotyped practices? I suggest that these dimensions are present in the process of change to more sex-equitable science and technology education, training and employment.

Before persons become committed to work for change they must experience some degree of dissatisfaction with the status quo. An employer or a training body may encounter skills-shortages, science educators become discomfitted by the low participation of females in their courses and feminists deplore the loss of power and opportunities for women, if the latter are not as fully involved in science and technology as men are.

The change must be acceptable. Although most people these days accept the principle of equal opportunities for both sexes, this does not necessarily mean they are prepared to work for a less sex differentiated society. They assume sex roles are natural and abilities of men and women differ. Because, in particular, men may feel personally threatened by the changes involved in de-stereotyping behaviour, acceptability has been emphasized in terms of their professional commitment to the education, training and employment of young people, (Whyte, 1986).

The relevance of de-stereotyping for the actual students, trainees or employees for whom responsibility is assumed must be recognized and ways of changing the sex differentiated situation must be visible. In other words, the change must be seen to be feasible.

The Fawcett Society intervened in the process of change at a number of points when new initiatives were introduced into education and training in Britian in the 1980's

Seizing opportunities

One of the functions assumed by the Fawcett Society's Education Committee is to monitor developments in education for any, usually unintended, consequences which disavantage one sex rather than the other. The Employment Committee monitors conditions of employment changes and they collaborate in the area of training. In the field of science and technology those disadvantaged are generally girls and young women.

In 1983 the government introduced the Youth Training Scheme (YTS) which was managed by the Manpower Services Commission (MSC). The courses within the YTS were initially for one year's duration but, from 1986, were extended to two years. The two-year YTS is employer-financed, it has largely replaced former apprenticeship schemes and is being interpreted as a means for producing a more skilled and flexible work-force.

Early anecdotal reports suggested that the 'new wine' of YTS, was being poured into the old 'bottles' framework of sex-stereotyping; the young women were entering secretarial and service training and the young men the more technical or 'heavy' areas. But hard evidence was needed before an approach could be made to the MSC.

The Fawcett Society members, collaborating with the National Joint Committee of the Working Women's Organizations and financed by a number of small donations, set out to survey young women on first year of YTS programmes in each of the nine regions of Britain.

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The report commented:

> 'Although there was little evidence of blatant sex discrimination, we found discrimination occurring in many less obvious ways. One was in the pressure on girls who were working on their own in a group of boys. More should be done to give them support. Just as serious from the point of view of equality was evidence of over-protectiveness towards the girls by parents, by the school, in the careers office, or on YTS schemes. Girls were often advised against taking-up such careers, sometimes with the best intentions, because they were not likely to find employment afterwards', or 'the work was unsuitable for them', or was 'unfeminine'. Even when girls have been accepted for training in non-traditional skills, there is evidence that they may face sex discrimination and harassment during training. There were a few YTS schemes, which were based on the experience of a well-established company training programme, which really did appear to encourage girls to seize their opportunities and qualify alongside the boys. These made provision for additional technical help during the initial stages of training and for emotional support. But these were outstanding schemes; there were other schemes, including some ITeCs, where training options and work experience differentiated markedly between girls and boys who were on the same scheme.

Its recommendations to the MSC included:

> 'Ensure that an equal opportunities policy, which includes a disciplinary procedure, is clearly stated and carried out in every YTS scheme through:
>
> (i) training of trainers in the meaning and implications of the policy.
>
> (ii) monitoring of policy more effectively.
>
> (iii) regular inspection and where necessary imposition of sanctions.
>
> (iv) checks on the quality and breadth of on-the-job training.
>
> (v) dissemination of good practice.
>
> Ensure provision of more non-traditional training for girls through:
>
> (i) Girls only schemes, and reserved places for girls.
>
> (ii) 'Access' courses for girls.
>
> (iii) Taster courses for girls in non-traditional areas of work in both Mode A and Mode B schemes.

Ensure better publicity for non-traditional training in local radio and newspapers, girls' and women's magazines with:

(i) advertisements appealing directly to girls.

(ii) Publicity about successful girls on non-traditional schemes, and good schemes.

The Fawcett Society (1985).

In the months following the publication of the report those most closely involved in the study were invited for discussions with senior personnel at the MSC. The Commission now requires each YTS training body to state its Equal Opportunity policy and to spell out how it will be implemented. In February 1986 it reported that a new package of measures designed to promote equality between the sexes in two year YTS had been endorsed by the Youth Training Board. This package contained six points, five of which were drawn from the report's recommendations. The sixth was a proposal for a national conference to address the issue of sex-stereotyping and look at ways of disseminating good practice (Samuels, 1986).

Dissatisfaction had been created through the presentation of evidence and the operation of public pressure. A commitment to equal opportunities had been expressed: the issue had become professionally acceptable. Moreover, the relevance of a change in sex-stereotyped patterns had been demonstrated for young women of a wide range of educational backgrounds, not merely for the high flyers to meet the shortage of graduate engineers.

Within full-time education a further development was taking place: the Technical and Vocational Educative Initiative (TVEI) for the 14-18 year olds, also supported by the MSC, who, in 1983 invited proposals for projects from local education authorities (LEA's). The first round of 14 projects extended to some 60 and then to around 100 in subsequent years. The intention is that all LEA's will run pilot projects which will later be extended to all their schools.

The first listed criterion for TVEI project proposals to be acceptable for funding by the MSC was that Equal opportunities should be available to young people of both sexes and they should normally be educated together on courses within each project. Care should be taken to avoid sex-stereotyping .

However, a Women's National Commission survey of the position of girls in the first TVEI projects had reported extensive sex-typing (WNC 1983). The MSC Chairman, in correspondence with the WNC General Secretary, referred to the criterion and commented: We are however very conscious of the problem of translating intentions into practice and would welcome any suggestions that would contribute to the task of changing attitudes of students, parents, teachers and employers'. He was appealing for illustrations of feasibility.

The Fawcett Society's Education Committee then launched a further initiative, proposing an Awards for Positive Action Scheme for those providing education and training for 14-19 year olds. It wished to identify good practice in enabling young women to participate in non-traditional areas of study and training (demonstrating feasibility) and to give recognition (in the form of certificates) to those taking action. The good practice was then disseminated in two ways: through a conference at which certificates were presented and where young people participating in the schemes talked about their experiences, and through a report of both scheme and conference. (The Fawcett Society, 1986). Local newspapers in the home areas of award winners were alerted, and carried features and reports of the positive action. This was both gratifying for the winners and contributed further to dissemination.

Funding for the Award Scheme was obtained from a number of sources: the Equal Opportunities Commmission, the Engineering Industry Training Board, the MSC and the Fawcett Society. The Awards were also offered again in 1987, following the promotion of 1986 as Industry Year . This time the target group was young women aged 16-25 and the MSC has promised most of the funding.

The interaction between a voluntary organization and those managing education and training developments, described above, is put forward as a model in which limited resources may be used most effectively. It requires a careful monitoring of developments and of the climate of opinion, an understanding of the process of change and a commitment of time and energy!

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WOMEN's AND MEN's ORGANIZATIONS. On female engineers.

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INTRODUCTION

In this paper we will use data from a research project on male and female graduate engineers, their career plans and career development. In Norway now, the percentage af women entering this profession has risen dramatically. 30% of the students at the tecnical university of Norway are women.

In Norway the engineering profession has traditionally lead to high positions in society. We wanted to see if this also is the case for the rapidly increasing proportion of women entering the profession.

It is no doubt a fact that in Norway as well as the rest of the western world there are very few women in management positions. If we take a closer look at the explanations that are given for why this is the case, we will often find the following types of explanations: women havent got enough education-or women haven't got the right education-or women haven't got enough self-confidence - or women haven't got any ambitions - or women will rather have a familiy than a career. As we see the main focus is on negative qualities with women. The solution which is suggested is just as simple: women must change. We must send them to seminars and courses where they can be given more self-confidence, they must learn how to become tougher. At least this is the case in Norway where arranging these types of courses have become a whole new industry.

Aren't these only the popular and the easy explanations? We have found that they are very widespread opinions and we also found quite a few examples of this in the research litterature (ref. Terborg 1977, Donell & Hall 1980).

We began to get very dissatisfied with this type of explanations. We asked ourselves why so few researchers have taken a closer look at how the companies are organized, how decicions are taken, how the work is organized and distributed. In sum: how the company functions as a work organization.

We felt that this had to be of great importance for what opportunities women are given and what kind of career they can have. There has always been agreement to the fact that this has importance for mens opportunities.

In work research, Feldberg and Glenn (1979) criticised other researchers for using different criteria to explain men's and women's work behaviour. They find that women's work behaviour has been explained too much on the basis of a sex-role model. In their opinion greater stress should be laid on the importance of working conditions, in order to understand women's work behaviour. This aspect is central when men's work behaviour is studied.

We consider it important to look at the constraints and opportunities of the various work organization. We are supported in this by Rosabeth Kanter's comprehensive study (1977) of men and women in a large American corporation. She shows how the structure of the organization and the male management practice in the companies create barriers to women's career opportunities; ideas of what is considered feminine and what masculine create and sustain a sex-segregated work structure. This in its turn make mobility patterns different for men and women in the same company. Thus in order to understand men's and women's behaviour in a work organization it is important to look at the structure of opportunity in the organization. This is one of the main aspects considered in the study of female graduate engineers.

We therefore wanted both to see how the organizations function and also look for any possible differces between men and women.

CONFIDENT, COMPETENT AND WILLING

By choosing female engineers we certanly didn't find women with either too little or the wrong type of education or training. They are a group of women with high education, which there is a great demand for in the norwegian society.

Neither did we find that the female engineers in our study lacked self-confidence. We found that they had confidence in themselves as engineeers.

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We found very few women who did not want management responsibility. Of the "older" women in our material (5-15 years' experience) most hold management positions. The younger ones are in line for promotion in the group who will have their turn soon. Many are considering leaving if they are not given the chance of new challenges. In this way they are like men.

To sum up we can say that they are confident, competent and also willing.

Our study showed quite clearly how important it is to have a closer look at now the companies are organized. Women's chances of being well received, shown confidence and given new tasks we find vary greatly form one company to the other and also partly within each company. For the sake of the argument we have made two more general models who represent ideal-types. We found two main groups of companies, one type which gave women good opportunities and the other which didn't.

The two types we have called static and dynamic organizations. In the static organizations we find a strong hierarchy with bosses who make all the decisions, and with a strong division of labour. In the dynamic organization we find a more decentralized structure, where people work in teams, and the tasks are not strictly defined and they vary over time.

We find that the static organizations do not give women good opportunities and the dynamic organizations provide good career possibilities for women.

Those companies which belong in the dynamic group operate in rapidly changing surroundings which demand flexibility and adaption f.ex. engineering firms and companies operating in fields of rapid technical development like electronics (Burns & Stalker 1961). Only private companies are represented here. Among the static organizations we find the publicly owned companies and the majority of private firms. This stands in clear contradiction to the general opinion in Norway. We have always looked upon the companies owned by the state as the best place to be for women. The bureaucratic organization with well-defined tasks and objective, neutral criteria for promotion was supposed to give women protection from discrimination.

As we have said our study shows that it is the dynamic organizations with the non-formalized criteria for promotion and without strictly defined tasks, which turn out to be the best for our female engineers when it comes to carreer opportunities. How can we explain this? Now we will take a closer look at the two types of organizations in order to explain this. We will do this by systematically comparing the two types of organizations.

HIERARCY VERSUS TEAM-WORK

In static organizatins you have influence when you have a position high up in the hierarcy. At every step in the organization you are told what to do by your manager. The manager also decides whether the work you have done is good enough.

In dynamic organizations the work is organized in groups or teams. Here the engineers work together as equals and they all take part in the decicion making according to their qualifications. It is your qualifications that count, not your place in the hierarchy.

This difference turns out to be very important for the female engineers when they enter male-dominated organizations. As a minority, or one by one, the women engineeers are very visible. Everything they do, and their appearance is noticed by their male collegaues. This could have been a pre if it had been your job performance which was being made visible. However, this is not the case. The things which are noticed is not performance in their jobs, but rather what makes them different from the majority, namely the men. The male majority tend to focus so much on the sex-characteristics of women, that they can't see them as professionals (Kanter 1977). Our point is that the conditions for changing these attitudes are different in the two types of organizations we have described.

In the dynamic organization where women and men work together in teams of equals, and where everbody is important in order to get the job done, it turns out that it doesn't take long before the women are recognized as professionals. In static organizations, however, we find that the women can wait for years before they get any comments or reactions to the job they do.

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BOSS VERSUS COORDINATOR

The functions of the manager in static and dynamic organizations are different. In the static organizations you find a very sentralized structure for decision-making. The communication between differnt parts of the organization goes through the hierarcy in such a way that the manager is the main information channel. The manager in dynamic organizations does the decision-making in cooperation with his/her collegaues who have the relevant information. The qualties needed for beeing a manager in this type of organization coincides whith the qualities the women in our study stress as important for managers to have.

The women, much more than the men, had well considered opinions on the role of managers. They stressed social skills: being able to co-operate, to delegate tasks and responsibility, to listen and to inspire and organize other to do a good job. One of them said: "I work so that I can make myself superfluous and get on with new tasks." Men mentioned the ability to be incisive, to make decisions, and to set goals, and some also mentioned the ability to co-operate. These are the qualities needed for a manager (boss) in a static and hierarchic organization.

Women put more stress on the importance of social skills in the job of manager and many had also experienced that they had such skills themselves. Their experience of success in building up a good team with openness, an informal tone and co-operativeness had given them extra confidence to undertake the responsibility of a manager.

In short the women in our study wanted the role of the manager to fit into a team-model where the manager's main job was to be a coordinator who delegated responsibility. This we also find in other research studies (Ressner 1985, Gunnarsson & Ressner 1983, Foged & Markussen 1984).

PERMANENT VERSUS FLEXIBLE ORGANIZATION

In a static organization all positions and tasks are well defined. In order to change your field of work you have to apply for another job. If you want more responsibility and influence you have to climb the hierarcy-ladder. To have a career means climbing the ladder.

You have to have the right qualifications in order to get a job further up in the hierarcy. All the engineers are in principle qualified. Wether you get a position higher up therfore depends on the what kind of person those who decide want. From other studies we know that managers choose new managers who resemble themselves, the same educataion, same class, same sex, same race. Those who resemble them are thought to think in the same way and make decisions as they would. So if you are a women on one of the first steps of the hierarcy ladder who aren't very visible as professional, and in other ways don't resemble the male managers, you don't stand a very good chance here. Men, however, who are both more visible as engineeers and also look like and behave like their superiors, stand a good chance.

In dynamic organizations it is quite usual for the employees to take part in defining and redefining their tasks and attempting completely new or different tasks. They are encouraged and supported in this. In this way they can develop their job and widen their area of responsibility. They can gradually aquire management positions, also without applying for a new job, and they are often invited by either collegaues or their managers to take on managerial jobs. This kind of job-development and career pattern suits the women.

The women we interviewed did not want to be a boss with many people under her without influence. They wanted to be manager in a group of equals. They are critical to the way many men take part in the race for the top. They criticise the men for doing a lot of unnecessary travelling on the job and overtime working. Some see this as what they call "false overtime" or "cockfighting" by the men as a way of displaying their importance for each other and the firm in the race for the top. Some of the women felt that many men considered themselves irreplaceable and therefor had problems f.ex. sending their colleagues on journeys or to meetings.

We also find that some of the female engineers who are in management positions change the travelling routines and the extensive use of over-time when they take on the job. They distribute these kinds of duties among the team-members. They also refuse to take part in management-meetings which start at five o'clock in the afternoon. So they manage to change the routines.

CONCLUSIONS

We have here tried to stress that the traditional explanaations, which all seem to concentrate on the "wrongs" with women, they won't and they can't, can not be used in an understanding of women engineers career patterns. We find that the women in our study both can and want to have a career. We find, however, that they have their own opinions and values on how their carreer pattern should be, what kind of work organization they want and what the managers role should be.

They want teams of people working in cooperation, and not the sentralized hierarchy. The manager should be more of a coordinator in a team of equals, and not a boss with many subordinates. They prefere to delegate jobs, and they don't need to control everything. They want a flexible joborganization according to qualifications and not a strong division of labour.

From what we have said here it is obvious that the different companies' organization structure and decision-making pattern is crucial for wether women get the opportunity to have a career. That is a carreer which is in correspondence with their own values. When women's scarcity in top managerial positions in society so often is interpreted as "women's lack of courage or will-power", we will say that this is because they are understood as deviants in relation to the appropriate career pattern, which is men's pattern. If we move our perspective from men to women, women's career pattern can be understood as critic of men's organization and management style.

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GENDER DIFFERENCES IN COMPUTER KNOWLEDGE, LITERACY AND COMPETENCY

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Following the dramatic ten-fold increase in the numbers and proportions of undergraduate women in engineering programs nationwide that characterized the 1970s, relatively small increases in the United States of women in engineering studies have been observed thus far in the 1980s. On the other hand, rapid changes have occurred both in the pre-college experiences of entering engineering students and the levels of computer knowledge, literacy and competency now required of engineering students and graduates.

Recent dramatic changes in the computer industry are having a strong impact upon industry, business, government and education that requires concomitant changes in engineering and technology curricula. Criteria of the Accreditation Board for Engineering and Technology (ABET) in the United States now include computer-based experience as a required part of the ABET-accredited college engineering programs:

> Students must demonstrate knowledge of the application and use of digital computation techniques to specific engineering problems...for example, the use of computers for technical calculations, problem solving, data acquisition and processing, process control, computer-assisted design, and other functions and applications appropriate to the engineering discipline (ABET, 1985, p. 100).

Moreover, related "computer literacy" requirements are also being made for ABET-accredited baccalaureate programs and engineering technology:

> Instruction must be included in one or more of the computer languages commonly used in the practice of engineering technology...Following formal instruction or demonstrated proficiency in programming, students should gain experience using the computer in appropriate technical courses (ABET, 1985, p. 164).

College computer courses must reflect the myriad of changes in both computer hardware and computer software, together with anticipating the diverse future demands for computer expertise that will characterize the various engineering and technology fields.

Because of the growing need to provide relevant learning experiences, engineering educators have become increasingly cognizant of the wide range of abilities and background experiences of students entering various engineering and technology programs (LeBold et al., 1986). Consequently, the focus of this paper is upon the interrelationships among the computer demands of society, the declining number of women enrolling in engineering programs and other relevant factors derived from both national and institutional studies of computer knowledge, literacy and competency. Specific attention is given to gender differences in these relationships.

Pre-College Computer Experiences

Students now entering college have more experience with computers than that of previous students. Only 20 percent of the first-year engineers at Purdue University in 1979 (N = 1500) had taken at least one pre-college course in computer programming, compared to 40 percent in 1985 (N = 1570) and 70 percent in 1986 (N = 1560) (LeBold et al., 1986). Moreover, students now enter college with knowledge of more than one computer language. In 1986, 24 percent of the first-year engineering students at Purdue University knew two or more computer languages, compared to 20 percent in 1985 (Armstrong, LeBold and Linden, 1986). The problem, however, concerns whether there are gender differences in the pre-college experiences with computers among entering engineering students. If gender differences do occur, are they related to the declining numbers of women enrolling in undergraduate programs in engineering?

Women and Computers

The possible impact of gender differences in pre-college experiences with computers upon enrollments of women in engineering, technology and science curricula should not be ignored. The question of gender differences in pre-college computer access and usage has drawn particular interest from researchers during the past few years (Armstrong, 1986). In California, a statewide assessment of computer literacy among 6th- and 12th- graders led to the conclusion that girls either have, or take, fewer opportunities to work on computers than do boys, both at home and at school (Fetler, 1985). Moreover, Boss (1982) reported that girls did not have the same amount of time on computers as did boys, because girls did not take the time needed to learn how to use the machines.

The results and conclusions of these studies are congruent with those of Sheingold and colleagues (1983), whose research indicated that males in all grade levels have more computer access and usage than do their female peers.

Moreover, computer access and usage at the secondary level were polarized by mathematics/science courses versus business courses, and girls tended to use computers primarily in the business area (Sheingold, Kane and Endreweit, 1983).

Gender differences in pre-college access to and use of computers have been found in homes as well as in schools. Hess and Miura (1985) indicated that families are more likely to buy computers and relevant software for male children than for female children. These researchers also found that three times more males than females registered in computer camps, with differences more pronounced at the secondary level than at the elementary level.

Gender differences in favor of male students were found for expressed interest in computer-programming courses (Becker, 1982; Fetler, 1985; Hess and Miura, 1985), with differences widening at the advanced levels of education (Lepper, 1985). Similar discrepancies for participation in advanced courses in computer programming were also found (Lepper, 1985). Moreover, Linn (1985) reported that, while women comprised 86 percent of the students in word-processing courses, women were only 37 percent of the students in computer-programming courses.

Data derived from a Computer Literacy Scale (CLS) administered to first-year engineers at Purdue University in 1985 indicated that significantly larger percentages of men than women had written and debugged programs, listed a program, saved a program, renamed a program, used a program to solve a mathematics problem, modified someone else's program, instructed others in the use of a computer, documented a program, used a word-processor and used a computer at home (Armstrong et al., 1986; Armstrong, 1986; Armstrong, LeBold and Linden, 1986). Similar gender differences in a 1986 replication study are presented in Figure 1. The only item on the CLS scale that did not identify a gender difference concerned using a computer at school, for which 91 percent of all freshmen had pre-college experience. With regard to course work and computer languages, first-year engineering men reported having completed significantly more weeks of high-school instruction in computer programming and knowing more computer languages than did women students (Armstrong, LeBold and Linden, 1986). No significant gender difference was identified for grades in computer-programming courses.

Gender differences in pre-college computer experiences have been attributed by some researchers to differences in interests and attitudes (e.g., Becker, 1982; Fetler, 1985; Hess and Miura, 1985). However, once males and females are enrolled in the same computer-programming course, their interest levels tend to be similar (Schubert, 1984). Researchers have proposed a myriad of reasons for observed gender differences concerning interests in and attitudes toward computers. These reasons include sex stereotyping that begins as early as the second grade (Stein and Smithells, 1969), traditional differences in mathematics and science (Lockhard, 1980; Winkle and Mathews, 1982), the placement of computers primarily in mathematics and science classrooms (Saunders, 1979), gender differences in spatial abilities (Aiken, 1972), public stereotyping of the computer as a man's machine (Hawkins, 1985) and the male-orientation of the major proportion of available software (Miura and Hess, 1984). All of these reasons, as well as others, help to explain the observed gender differences in interests and attitudes.

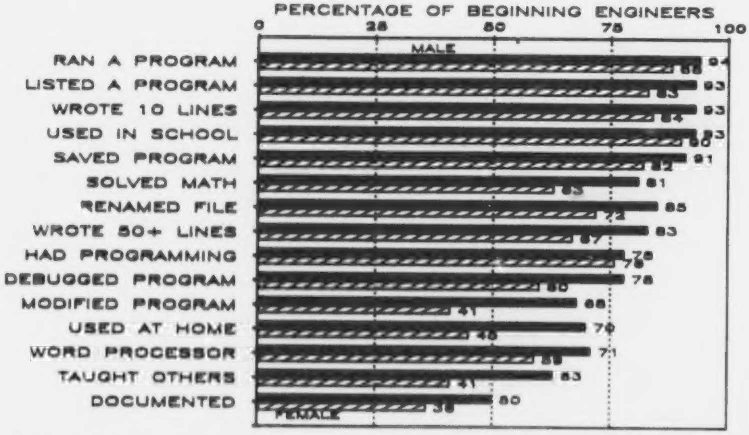

Figure 1. Gender Differences in the Percentages of 1986 First-Year Purdue Engineering Freshmen Responding "Yes" to Individual Items on the Computer Literacy Scale.

Bandura (1982) has proposed self-efficacy (self-appraisal of one's ability to complete a task successfully) as a factor that may determine whether a person will engage in a task. In the computer field, Miura and Miura (1984) reported that male students had significantly higher perceived self-efficacy for computer-related tasks than did women. Gender differences in self-efficacy were also found among junior-high-school adolescents (Miura, 1984). Women engineering students reported lower perceptions of their abilities than did men (Linden et al., 1985). Self-perceptions of abilities and self-efficacy may, in part, explain gender differences in enrollments in computer-programming courses.

If males do possess higher levels of interest in and experience with computers and have more positive perceptions of their abilities than do females, do males surpass females in computer-programming courses? In general, research indicates no significant difference in academic performance between male and female students, even when significant gender differences are present at the beginning of the course (Campbell and McCabe, 1984; Mandinach and Fisher, 1985; Armstrong, 1986; Armstrong, LeBold and Linden, 1986). However, one study did indicate that elementary-school boys exhibited higher levels of achievement than did girls in LOGO programming (Pea et al., 1984).

There is considerable evidence in the research literature to suggest that, in the pre-college years, males tend to have higher levels of interests, access and participation in computer-related activities, including games, computer camps and computer-programming courses, than do their female peers (LeBold, 1986). However, the relevant question at this point is to ask whether or not these gender differences in pre-college computer activities and interests affect academic performances in college-level computer courses and computer-related programs.

Gender Differences in Predicting College Achievement

Research concerning predictors of academic performance in college-level computer courses have been focused upon mathematical abilities (e.g., Alspaugh, 1972; Peterson and Howe, 1979; Mazlack, 1980; Ralston and Shaw, 1980; Stephens, Wileman and Konvalina, 1981), reading ability (Stephens, Wileman and Konvalina, 1981), writing style (Kagan and Douthat, 1984) and selected personality traits (Alspaugh, 1972). The research literature indicates that the strongest predictors of performance in college-level computer courses are high-school grade-point-averages, mathematics grades, science grades and *Scholastic Aptitude Test* (SAT) Verbal and Mathematics scores (Campbell and McCabe, 1984; Koubek, LeBold and Salvendy, 1985). However, these predictors tend to operate differentially for girls and boys, particularly college-admission mathematics test scores (e.g., SAT-Mathematics; American College Testing Program: ACT-Mathematics) which have been identified as the best predictor of grades in college computer-programming courses.

There is general consensus that gender differences in college-admission mathematics test scores can be accounted for primarily by gender differences in the numbers of mathematics, physical science and computer programming courses taken in high-school by women compared to their male peers (LeBold, 1986). Moreover, both prior to and during college, women tend to be less likely than men to engage in extracurricular and personal activities that could enhance quantitative and physical-science activities (e.g., computer camps and home computers) and mechanical or other problem-oriented activities (e.g., construction and/or electronic hobbies, reading popular technical magazines, etc.).

The study conducted by Armstrong (1986) was designed to identify gender differences in pre-college variables that would predict performance in various college-level courses, particularly courses in FORTRAN and Pascal computer languages. The Computer Literacy Scale (CLS) was administered to more than 1500 freshman engineers entering Purdue University in the fall of 1985 (Armstrong, 1986). CLS scores were correlated with grades in various college courses, including courses in computer programming, calculus, physics and foreign languages. Armstrong found gender differences for several pre-college variables, including computer literacy and high-school rank. The average high-school rank of first-year college engineering women was significantly higher than that of men, while pre-college level of computer literacy was significantly higher for men than for women. However, these variables did not predict gender differences in academic performance in college computer-programming courses, results that are congruent with those of Campbell and McCabe (1984) and others. It was concluded that this group of first-year women engineers at

Purdue University overcame their differences in pre-college computer knowledge, literacy and competency, perhaps because of their overall superior level of high-school achievement.

In a recent study conducted at Purdue University (LeBold et al., 1987), gender differences in self-reports of computer expertise were observed among first- and third-year students majoring in computer-related fields (industrial, electrical and computer engineering; computer and information science; computer technology). As noted in Figure 2, first-year male students had much higher mean scores (standard T-scores) for the variables studied than did first-year female students. However, these gender differences tended to disappear for third-year students. The results also indicated that first-year male students believed computer-programming tasks were easier for them and expressed more confidence in their computer abilities than did first-year women students. These differences were not found for third-year men and women majoring in computer-related fields. Thus, women who persist in these fields of study in college appear to become as experienced, interested and self-confident in computer tasks as are their male peers. Consequently, there appears to be no reason why younger women and girls should be wary of working with computers.

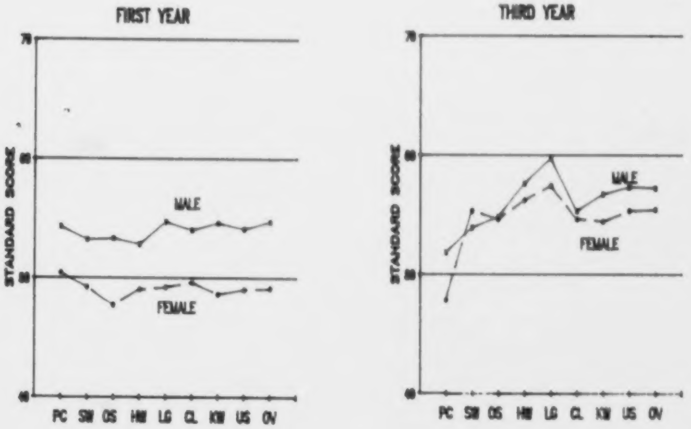

Figure 2. Mean Standard T-score Profiles for First- and Third- Year Male and Female Computer Majors Including Personal Computer (PC), Software (SW), Operating Systems (OS), Hardware (HW), Languages (LG), Computer Literacy (CL), Knowledge (KW), Use (US), and Overall (OV) Computer Scales.

Summary and Conclusions

In this report, we have noted significant differences in computer interest and experience of young men and women in the United States who are completing high school and entering college. Even among students entering the computer-related fields of engineering, science and technology, men tend to report having stronger pre-college experience in computer courses, languages and related skills than do women. However, generally there is no significant difference in academic performance in computer-programming courses at both pre-college and college levels. Moreover, although gender differences in computer interests and confidence in one's own computer skills have been reported by first-year students majoring in computer-related fields, these differences disappear among third-year students. These results suggest that high-school girls who expect to attend college should not be reluctant to work with computers.

The demand for computer experiences by industry, government, business and education appear to be related to the decline of enrollment in engineering programs that have been observed for women in the 1980s, as compared to the 1970s. Noting a lack of interest in enrolling in computer courses by women, even though no gender difference in academic performance in such courses was observed, Linn and Dalby (1985) concluded that securing the participation of women in programming courses now appears to be the central issue for equity in engineering, technology and science programs. The key to equity for women is to unlock this apparent barrier. Women *do* gain as much computer knowledge, literacy and competency as do men. Women should not reject engineering, science or technology fields of study because of reluctance or fear of the computer demands now required by these programs. Were this perceived barrier to be broken, enrollments of women in engineering and other computer-related fields would surely increase once again.

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TEN YEAR STUDY OF WOMEN PERFORMANCE IN SCIENCE SUBJECTS AT KENYATTA UNIVERSITY (1977-1987)

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INTRODUCTION:

Ever since the introduction of University education in Kenya, the Kenyan male has dominated the Science and Mathematics subjects. This scenario has been created by several factors and unfortunately it will continue for several years to come, in spite of the government's concerted effort to equalize the academic opportunities. In the first instance, the sheer number of girls enrolled in secondary schools offering science and mathematics is less than boys secondary schools (Eshiwani 1984, Marangu 1985). The Universities of course draw from the secondary schools. Secondly, although the general population has accepted that the restriction of certain subject to male students is a myth, and lag effects of what it used to be still haunts female education. Consequently, even at Kenyatta University the majority of women students are enrolled in the faculties of arts and education.

The purpose of this paper therefore is to study the enrolment of female students at Kenyatta University for the past academic years, 1977-1987. Also we hope to analyse their performance and compare it with that of their male counterparts.

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HISTORICAL BACKGROUND: KENYATTA UNIVERSITY

Kenyatta University campus was originally a British Army Base during the colonial era. In 1965 the British Government handed it over to the Kenya Government for use as an institution of higher learning. Its aim was to produce non-graduate secondary school teachers. In addition, the institution included a science oriented secondary school.

In 1972 the Kenyatta University College was established as a constituent college of University of Nairobi and the secondary school section was phased out the following year. The main objective of the new University College was to offer degrees of Bachelor of Education in Arts, Science, Fine Arts and Home Economics.

In this paper, our concern is mainly on the degree of Bachelor of Education in Science. The subjects covered are Mathematics, Chemistry, Physics, Botany and Zoology.

ENROLMENT OF WOMEN INTO THE FACULTY OF SCIENCE

During the past decade, the enrolment of women in the science subjects at Kenyatta University has been on a steady increase. Table 1 reveals that the first year women students have increased from the initial 29 in 1977 to 100 in 1986. This increase is impressive but when you consider the total of 1st year students admitted during the 1986/87 academic year, this is only 28%. What we have to keep in perspective is the fact that there is competition for the limited positions at the University and the increased intake of girls means a decrease in male intake. The data for the year 1979/80 were not available and the University was closed during 1982/83 due to student unrest. The enrolment for the second year within the 1977-87 study period followed the same pattern as the first year. Table 1 shows also that during the academic year 1978/79 the enrolment reached 336. This was due to the Faculty of Education moving from the University of Nairobi to Kenyatta University College and the number of students in the Bachelor of Education in Science subjects is reflected in this figure.

Each third year enrolment throughout the past ten years has always been smaller than the first and second year groups. This is due to a number of reasons, including failure to meet the standard, repeating a year, expulsion and personal reasons.

Enrolment of women in the third year has actually increased more than threefold during the last ten years. In 1977/78 the third year women numbered 19 and this has reached 66 during the 1986/87 academic year. If the current trends were maintained the number of women of the graduating class of 1989 would be about one third.

GRADUATING CLASSES 1977-86

Kenyatta University gives four classes of degrees according to the individual performance. The highest honours degree is First Class. The next to the highest is the Upper Second Class Honours and the third is the Lower Second Class Honours. The lowest degree conferred is Pass.

Figure 1 shows the percentage distribution within each sex group and the degree category. Also the actual number of candidates awarded degrees is shown. In addition there is a group of failed and discontinued students.

The total number of graduating students (women) throughout the last 9 years in the faculty of science reached 242

	YEAR I			YEAR II			YEAR III		
Academic Year	Female	Male	Total	Female	Male	Total	Female	Male	Total
1977/78	29	253	282	14	115	129	19	106	125
1978/79	40	170	210	27	309	336	18	158	176
1979/80	-	-	-	-	-	-	-	-	-
1980/81	74	297	371	59	209	268	59	124	183
1981/82	49	184	233	56	249	305	34	206	240
1982/83	-	-	-	-	-	-	-	-	-
1983/84	62	232	294	49	212	261	47	234	281
1984/85	64	251	315	51	163	214	49	209	258
1985/86	100	201	301	66	235	301	52	161	213
1986/87	100	255	355	69	183	252	66	238	1691

Table 1: Enrolment by academic year, year of study and by sex. 1977/87. Sources: Students Nominal Rolls, Kenyatta University 1977/8-1986/7.

having gradually risen from 16 in 1977/78 to 49 in 1985/86. This figure compares with 1422 male students during the same period of time.

The number of graduating women in Science and Maths has grown slowly and steadily during the last 9 years from 15 to 51 in 1986. During the same period, their male counterparts have actually reached up to 240 in 1983. The exceptional year was 1979 when their number reached 308 male students and this was due to the transfer between the Faculty of Education, University of Nairobi to Kenyatta University in 1978.

All things considered there is an improvement in enrolment and graduating women in the faculty of science and Mathematics but the growth rate needs drastic improvement. If only you can get the girls in the programme, their chances of completing degree programme are very high according to their previous records on Table 2.

CONCLUSIONS:

From the available data at Kenyatta University during the past 10 years, the number of women enrolled in science and mathematics had steadily increased. The increase is however not as high as it should be when one considers that the number of girls in secondary schools had reached 60% of the number of boys by 1979 and was still on the increase (Marangu 1985)

If the number of girls in science and mathematics subjects is to improve, there must be improvement in the secondary schools offering such subjects. Not only the improvement on quality but also quantity. Also, there must be incentive and

	FEMALE		MALE		
	GRADUATED	FAILED	GRADUATED	FAILED	TOTAL EXAMINED
1977/78	16 (12%)	0 (0%)	113 (86%)	3 (2%)	132
1978/79	15 (13%)	0 (0%)	101 (87%)	0 (0%)	116
1979/80	15 (5%)	1 (.03%)	303 (94%)	5 (1.5%)	324
1980/81	31 (20%)	0 (0%)	122 (80%)	0 (0%)	143
1981/82	29 (13%)	0 (0%)	195 (86%)	2 (1%)	226
1983/84	38 (14%)	0 (0%)	240 (86%)	0 (0%)	278
1984/85	49 (18%)	0 (0%)	208 (77%)	2 (1%)	259
1985/86	49 (24%)	2 (1%)	140 (69%)	12 (6%)	203
TOTAL	242 (14.3%)	3 (0.2%)	1422 (84.17%)	24 (1.42%)	1691

TABLE 2. Summary of performance among male and female students in obtaining first degree or failing during the years 1977-1986.

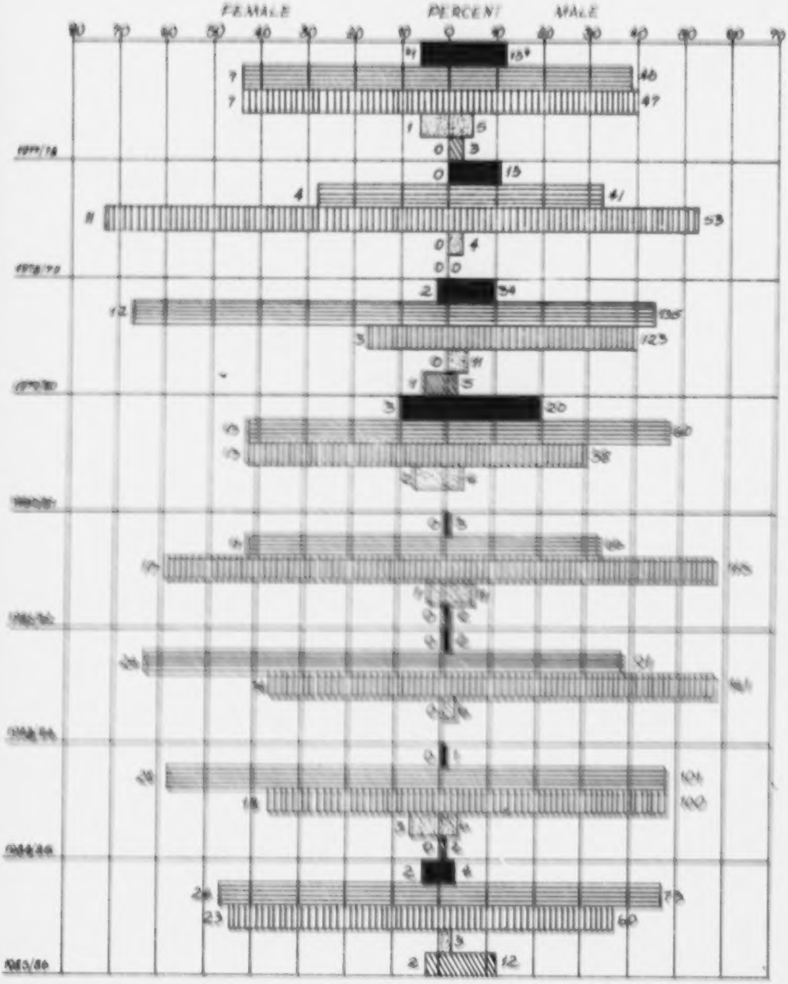

Fig. 1. PERFORMANCE IN PERCENT
Distribution by Sex and Grade on specific academic year from 1977/78 to 1985/86.
* Figure represent actual no. of candidates in a grade

KEY: Grade
■ 1ST CLASS HONOURS
▤ UPPER 2ND CLASS
▥ LOWER 2ND CLASS
░ PASS
▨ FAIL/DISCONTINUED

encouragement to the girls who are interested in science and maths subjects. This probably could be in the form of a quota for girls who are qualified for admission but due to lack of space in the University are left out. There should also be a follow up of the graduating women to seek from them suggestions on how to improve the situation.

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Girls Towards Degrees in Engineering – A National Need

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This paper presents the argument that a contributing factor to the Western World's shortage in engineering personnel is the fact that engineering talent was drawn from 50% of the population: girls and women were not considered as part of the national talent pools and less than 10% of engineering graduates were women. In the case of Israel – in 1985 only 3.6% of female but 27.8% of the male graduates were engineers. But data presented proves the availability of female talent and the economic feasbility of investment in its developement. Applying sales promotion techniques to initiate change and designing support systems to sustain changes in career choices during the transition periods – until women gain significant percentages all along the pipeline towards careers in engineering are proposed and discussed.

A. Introduction

The year 1983 will be remembered as the year when policy makers in Higher Education found themselves in a bind: they could not produce enough engineers and scientists to supply the needs of "HIGH TECH" industries and they had no ready explanations. When required to analyse how and why western society suddenly found itself in this kind of crisis ,that threatened the national economies and even national security(1), heads of governments and their education and labor ministries nominated special committees to investigate the reasons and recommend solutions(2).

The different committees reached almost the same conclusions:

a) there is a marked decrease in the numbers of young persons interested in the studies of Science and Engineering

b) there is a marked deterioration in the level of science education in the school system

c) there is a marked deterioration the general level of education.

In Israel, the Dvorezky Committee nominated by the Minister of Education,published its recommendations in July 1983. On the basis of these recommendations the Ministry of Education has initiated several measures:

1. A special committee for the Advancement of Science & Technology in Education has been set up in the ministry.
2. Mathematics (3 units) will become mandatory for matriculation starting in 1989(shortage of teachers prevents earlier implementation).
3. Allocations for training science teachers were approved.
4. Allocations for developing relevant curriculums were approved.

A major problem has not been discussed by the the Israeli Committee

HOW TO BRING MORE PUPILS INTO THE SCIENCE CLASSES ?

The possibility that the pupils might not be there when the new teachers will join the school system or the curriculums published and ready for use, did not come up. The assumption in Israel, as in most other countries, was that the pupils are "a captive audience", for the school system to mold and steer.

In this paper I will try to deal with this problem by

a) defining the potential populations for engineering personnel b) defining the methodology needed for drawing this potenial into the pipeline of careers in engineering

According to the data, to be presented later, I can state that

> THE MAIN POTENTIAL FOR ENGINEERING PERSONNEL IN ISRAEL ARE GIRLS AND WOMEN. ENLARGING THE NUMBERS OF CANDIDATES FOR ENGINEERING EDUCATION WILL DEPEND ON THE ABILITY TO PROMOTE INTEREST AND MOTIVATION AMONG HIGH-SCHOOL GIRLS AND YOUNG WOMEN AND IN DEVISING SUPPORT SYSTEMS FOR THEM AS LONG AS THEY ARE A MINORITY IN THE PROFFESION.

B. Background data (App. 1)

The Israeli school system today is either 6 + 3 + 3 or a 8+4 with more schools going into the american pattern of comprehensive high-schools. A special feature in our school system is the extremely large number of vocational high-schools offering a choice of matriculation or plain high-school certificates,in a variety of tracks from electronics & computers,through mechanics,construction, architecture,fashion design,home economics office technologies,etc.(82,568 pupils in general schools with 60% girls and 89,132 in vocational schools with 45% girls).

Higher Education in Israel constitutes of 6 universities offering undergraduate and graduate studies in a variety of subjects and 1 institute for advanced studies in the science. We also have a large number of teacher-training colleges,technical college and a variety of post-secondary programs.

Israel is an immigrant society:its Jewish population in 1945 was a mere 500,000 and through waves of immigration in the years 1946-7, 1949, 1951, 1956-7, 1967-73, we grew to 3,500,000. Most of the immigrants were refugees, fleeing from situations and countries where they had not enjoyed equal rights and opportunities, and where in many cases they had been persecuted because of their religion. It has taken time for our people to overcome the adverse situations,to bridge the gaps in education, to mature in the sense of becoming able to take full advantage of the educational opportunities offered.

It is therefore extremely important and interesting to examine the characteristics of the class of 1977, where most of the freshmen born in Israel and have had the opportunity to get all their education in Israel.

C. The class of 1977 (3)

1. General description(App.2)

9,200 new students started their studies in 1977:

51% were men and 49% were women. Of these 9200 –

75%	were high–school graduates with matriculation
11%	had governmental matriculations(dropouts who had second thoughts and chances)
10%	had equivalent certificates
04%	had overseas certificates

These statistics are relevant here because only those with high–school matriculation have specific information about high–school majors or tracks (number of units studied ,grades and average grades)which could be co–related to academic achievements and behaviours.

2. High–school achievements

The academic profile of the freshmen is measured, among other characteristics, by the grades in their matriculations. In the class of 1977

38%	had 80+ average grade (Hebrew+English+Maths),
47%	had 80+ in Mathematics,
44%	had 80+ in Hebrew.

Average grades taken for the different faculties show that:

45%	of Engineering and Science students had a 80+ average
33%	of Arts and Social Science students had a 80+ average

Taking Mathematics as an indicator –

75%	of Engineering	beginners	had 80+
62%	of Science	"	had 80+
50%	of Social Sciences	"	had 80+

Gender biased differences were found among the begginners and female students had higher matriculation grades than male students:

AVERAGE GRADES	43% of the females
of 80+	32% of the males
HEBREW	55% of the females
80+	30% of the males
MATHS(5 units)	59% of the females
	54% of the males
MATHS(4 units)	54% of the females
	50% of the males

The same proportions were found in the 90+ range of grades.

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3. Academic achievements

Table 1: Beginners choice of faculties by gender,(CBS Special Series no.772)

Faculty	100.0%	male–100%	female–100%
Liberal Arts	31.5%	15.6%	48.3%
Social Sciences	32.6%	37.4%	27.6%
Law	2.6%	2.6%	2.7%
Medicine	3.1%	2.9%	3.2%
Science(Agric.)	17.3%	19.0%	15.4%
Engineering(Arch)	12.9%	22.4%	2.8%

The follow–up study on the class of 1977 took place 4 years later,i.e. 1981. At that time 52% of the students have graduated, 21% were still studying(engineering,architecture and medicin take longer) and 27% have dropped out. Analysis by Zylberberg(4) of these three groups as to faculty andgender brought to light an amazing phenomena:

THE FEMALE STUDENTS WERE DOING MUCH BETTER THAN THE MALE STUDENTS

More female students graduated,

Fewer female students dropped out,

Female students graduated faster,

Female students achieved higher grades.

These statistics were true not only for the total population but also, and more pronounced even, when taken up in each and every faculty separately.

Drop–out rates,for example, were:

	male	female
Liberal Arts	48%	43%
Social Sciences	31%	22%
Science+Agric.	26%	21%
Engineering	11.3%(N=1063)	11.7%(N=125)

The explanation suggested by Zylberberg is that the female students success can be attributed to the higher level of their matriculation average grades,i.e. better academic preparedness.

Another point made by Zylberberg is that students with science majors in their high–school matriculations were doing significantly better than those who majored in social studies or humanities – in all three criteriae: graduation rates,graduation pace and smaller drop–out rates.

Other points worth mentioning:

Significant differences were found between the 6 universities as to the 3 criteriae – graduation rates,drop–out rates and pace of graduation. The Technion,Israels foremost school of Engineering with approximately 6,000 undergraduates in Science & Engineering came up first both in sciences, which are offered by all other universities, and in engineering – offered by 2 others.

It is therefore important to note that 21% of Technion students are women and that on October 1986 ,when 140 students were honored for excellence (90+ averages) 20% were young women!

We can therefore summarise as follows:

1. Israel has a shortage of well trained and qualified engineers.
2. Girls are doing significantly better than boys and investments in their education produces higher outputs.
3. 2.8% of the girls chose engineering but a much larger percentage has the academic preparedness and most of the specific prerequisits.

IT IS THEREFORE IN THE INTEREST OF OUR COUNTRY TO INVEST VIGOROUSLY IN SPECIAL OUTREACH PROGRAMS AMONG GIRLS AND WOMEN IN ORDER TO PROMOTE ENGINEERING AS A CAREER.

D. Human Resources Potential

We have showed above potenial successes in higher education as a whole and in engineering & sciences specifically. The question we have to raise and discuss relates to potential engineering candidates – now in the pipeline: girls in the various stages of their high-school education, their choice patterns and their achievements in a variety of science majors.

Table 2 Pupils in the 12th grade by science majors and gender (CBS,Survey of pupils in the 12th grade,1984 5).

science	Jewish		Non-Jewish	
major(4+units)	Girls	Boys	Girls	Boys
Mathematics	33.8	48.1	45.6	50.4
Physics	6.0	21.7	6.7	12.7
Chemistry	6.5	8.4	6.5	10.2
Biology	19.1	21.0	32.6	29.5
12 units Sc	19.0	31.8	38.2	44.9

TOTAL = 100%

When we break this data and separate the groups learning 5 units from those of 4 units by gender we discover a different picture altogether.

Table 3: Pupils in 12th grade by gender, science subjects and units (CBS .Survey of pupils in the 12 grade 1984/5)

Subject	5+ un	4un.	3un	other	Total
Maths					
Girls	12.7	21.1	64.1	2.1	100%
Boys	26.4	21.7	50.5	1.4	100%
Phys.					
GGis	5.2	0.8	2.8	91.2	100%
Boys	19.1	2.6	4.3	74.0	100%
Chem.					
Girls	2.2	4.6	10.6	82.6	100%
Boys	2.6	7.0	13.2	77.2	100%
Biol.					
Girls	18.7	0.4	7.4	73.5	100%
Boys	19.5	1.5	5.1	73.9	100%

Total population:14,717(9,220 girls ,5,497 boys)

Further investigations on choice and success in mathematics in senior high-school was undertaken by Amit(5). Amit analised the achievements of all pupils in 3 comprehensive high-schools of one town by gender,number of units and year in the high-school(11 & 12 grades). Amit found that although significant differences by gender were found in the enrollement rates in the different study groups(3,4,5 units) and very similar to those of CBS – no significant differences in achievement levels by gender were found within each group of 3,4, or 5 study units.

We have had quite a number of research papers on the corelations between various majors in high-schools and the academic choices made several years later. All of these papers and especially those written by Yogev and Kfir (7) point out that:

1. Most of the critical decisions are made in junior high.
2. In most of these cases decisions are made by school staff.
3. Only pupils placed in the A level of the 7th grade will have a chance to reach a track of 4+ units of science studies.
4. In most cases,especially those with middle and low SES, the pupils and their parents are unaware of the significance of these on-way-decisions for the future growth of their children, which in Israel has a time lag of 9 or 10 years (6 years of school and 3-4 years in the army).

It is clear,following the data, that we have here a natural setup for the implementation of an outreach program to attract young persons, specifically young girls, to think about engineering as a career and to study mathematics and physics and/or chemistry in high-school, since these are the prerequisits for engineering. Those pupils and their parents who might have their doubts about deciding on engineering as career choices will be reassured by the data that graduates with science majors will have a higher probability of success – both in being accepted to most institutes and most faculties and in the probability of graduating in optimal time and achievements.

E. Intervention model

With the problem as stated above I propose to deal in a multi faceted methodology based on the following statement:

> THE NUMBER OF ENGINEERS AT THE TOP OF THE PYRAMID IS A FUNCTION OF THE NUMBER OF PUPILS AT THE BASE WHO WILL BE ABLE TO STUDY MATHEMATICS AND PHYSICS AND ALSO A FUNCTION OF THEIR WILL TO STUDY THESE SUBJECTS.

a) Promote engineering as a prefered career choice for girls and women, using sales promotion techniques. The promotion of engineering as career choice will be aimed at 4 target populations:

the pupils
the school's staff
the parents
the pupil's peer goup

Differential approaches and materials will be developed as needed for the pupils and their 3 'significant others'.

b) Implement these techniques at 6 critical crossroads, critical because the girl and her significant others have to make decisions pertaining to her future personal growth, her level of education,her highschool majors,her options for higher education and her final decisions on a career and specialization.

c) Build support systems for pupils (and students) to help them stay with their choice despite being a minority – both during their periods of studies and later during their initial working years – until a 'critical mass' number will join the profession. The aims of these support systems will be to help overcome difficulties perusant to minorities in education(7): loneliness,loss of informal information that 'in' groups share, a tendency to intrepret objective learning problems as if they were problems of the minority to which they belong,poor self concepts. Further,and not less important, services to be rendered by these support systems will be in networking towards better job opportunities both as beginning engineers and later for managerial positions etc.

In Israel the 6 crossroads are as follows

1. First year of junior high – when the pupil has to prove learning skills and abilities in Hebrew,English and Mathematics in order to be placed in an A level class(which has been found crucial and conducive for academically oriented tracks).

2. Ninth grade – choice of type of high-school: general,vocational, agricultural etc.
3. Tenth grades 2nd term – choice of matriculation majors.
4. Twelfth grade's 2nd term – choice between ROTC and specific academic faculty and military service directly after graduation(within this there is also an option of pre-military 6-12 months technical training in a variety of subjects).
5. End of military service – choice of career area and choice of institute/school in which to study.
6. Second half of freshmen year – change of major or even institute, having tasted and grown wiser.

Working simultaneously on 6 crossroads will enable to muster and apply, test and check the effectiveness of our methodology on the different age groups and reach interim conclusions in a shorter time span than what will be needed when conducting a longitudinal follow up study: not having to wait up for the groups to mature throughout a 12 year period (6 years of high-school + 2 to 3 years in the army + 4 years in engineering) but only the 3 to 4 years of maturing from one stage to the next.

Final note

A detailed proposal along these lines has been presented to the Committee for the Advancement of Science, the Ministry of Education. The proposal has been approved for implementation on January 1987 and we are now waiting for budget approval.

We think that the major feat here is in having the proposal approved because policy makers recognised that this outreac program answers a national need and not only because of a partisan political pressure for equal reghts. Hopefully it may also mean that budgetting and allocations will be extended accordingly once we prove our points and the intervention model will be applied countrywide.

Notes:

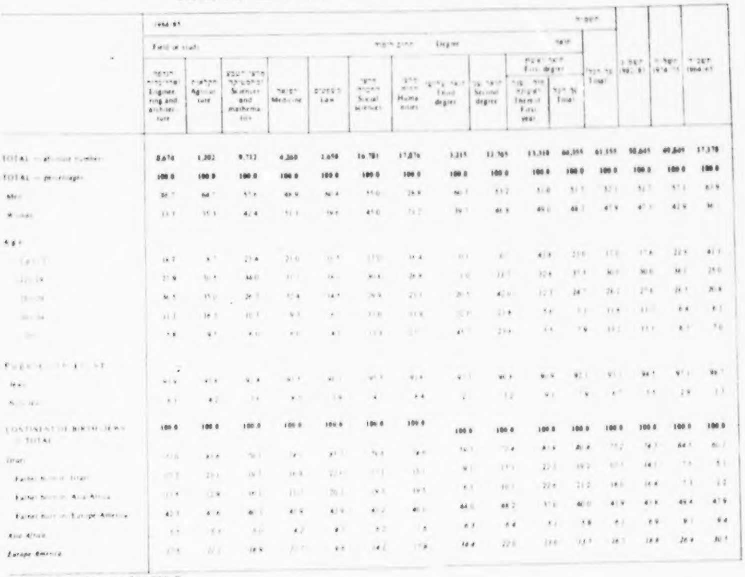
1. Prof. Josef Rom,National Strategies for Development of Human Resources, presented at the International Colloquium on "Developing Human Resources in a Rapidly Changing Society", Jerusalem, May, 1984.
2. Nation at Risk – A Presidential Commission The level of Science Education,April 1983
   Committee on the Policy of Science Education in Israel,Chairperson – Prof Arye Dvorezky,July 1983.
3. Course of Studies of University Undergraduate Students – Follow-up Survey 1976/77 – 1980/81, Central Bureau of Statistics (Special Series no.772) and the Planning and Grants Committee,The Council for Higher Education, Jerusalem 1986.
4. Zylberberg Ruth, Analysis of the CBS Follow-up Survey on University Undergraduates 1976/77 – 1980/81, prepared by request of the Planning and Grants Committee, Council for Higher Education, March 1986.
5. Amit Miriam, Sex Differences in Achievement, Level of Study, and Causes Attributed to Success and Failure in High-school Mathematics, Research Thesis for Master of Science, Dept. of Teacher Training, Technion, Israel ,October 1986.

6. Yogev & Kfir, Determinants of Curriculum placements in Israel High-schools: Ability Grouping & School Sponsorship Mechanisms, Megamot, Vol. 20, no. 2, December 1982

7. Yael Rom, A Multi-Stage Project for the Advancement of Under- Represented Groups Towards Higher Education in Science and Technology, The Van-Leer Jerusalem Foundation, presented at the International Colloquium on "Developing Human Resources in a Rapidly Changing Society", Jerusalem, May 1984.

APP. 1

TABLE XXII/31 — STUDENTS IN ACADEMIC INSTITUTIONS BY DEGREE, FIELD OF STUDY, SEX, AGE, POPULATION GROUP AND CONTINENT OF BIRTH



1 See introduction and note 1 to Table XXII/30.
2 Including diplomas.

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TABLE XXII/27. – PUPILS IN POST-SECONDARY EDUCATION, BY COURSE, YEAR OF STUDY, SEX AND AGE

Year of study, sex and age	Course of study מגמת לימוד							סך הכל Total
	Other courses	Arts	Clerical work, administration banking, economics and accountancy	Para medical occupations	Qualified nurses	Practical engineering technical work etc.	Teacher training for primary and intermediate schools	
1970/71	1,265	876	1,364	600	1,177	4,793	5,442	15,517
1974/75	1,801	1,835	2,351	607	1,219	7,355	11,229	26,399
1979/80	1,737	1,375	2,176	475	1,961	7,857	11,770	27,351
1984/85	874	2,028	2,001	746	1,567	13,892	12,905	34,017
1985/86 – GRAND TOTAL	**1,132**	**1,988**	**2,806**	**705**	**1,415**	**15,205**	**12,021**	**35,272**
Hebrew education – total	*1,132*	*1,988*	*2,806*	*705*	*1,415*	*15,013*	*³11,601*	*34,660*
Thereof: First degree students	167	991	216	—	—	702	⁴3,516	5,592
Year of study								
I	886	756	1,557	397	604	8,787	3,812	16,799
II	99	593	662	259	431	5,148	3,774	10,966
III	82	356	515	30	353	825	3,175	5,336
IV	65	283	72	19	27	253	840	1,559
Men	408	657	1,823	303	102	12,064	1,841	17,198
Women	724	1,331	983	402	1,313	2,949	9,760	17,462
Age								
18–24	289	1,412	621	567	1,065	9,572	*8,585	22,111
25–29	328	447	1,095	92	154	3,061	*3,016	8,193
30 and over	515	129	1,090	46	196	2,380	—	4,356
Arab education	—	—	—	—	—	*192*	*³420*	*612*

1 For differences between this table and Table XXII/9 see introduction. 2 See details in introduction. 3 See note 1 to Table XXII/28. 4 Incl. all first year through fourth year students in courses which are authorized or recognized in institutions that are permitted to grant B.ED. degrees.

APP. 2

TABLE XXII/40. – NEW FIRST DEGREE STUDENTS IN 1976/77, BY STAGE OF THEIR STUDIES IN 1980/81 AND VARIOUS CHARACTERISTICS

Percentages

	Dropped out		Studied		Graduated		סך כולל Grand total	
	Thereof in first year or before the second	Total	Thereof 5 years	Total	Thereof lagged 3 years or less	Total		
Total	12.9	26.8	15.6	21.5	20.6	51.7	**100.0**	**100.0**
Men	12.9	27.1	15.7	23.1	18.0	49.8	**100.0**	51.5
Women	12.9	26.5	15.4	19.7	23.3	53.8	**100.0**	48.5
Age at starting studies								
Up to 19	11.0	27.2	18.3	23.1	14.7	49.5	**100.0**	15.6
20—21	10.3	20.9	14.4	20.2	26.6	58.9	**100.0**	35.4
22—24	13.6	28.4	14.7	19.9	18.9	51.7	**100.0**	31.3
25—29	18.1	34.7	13.8	24.4	19.7	40.8	**100.0**	9.8
30—34	17.9	27.5	(21.9)	30.6	(21.0)	41.9	**100.0**	3.0
35+	18.5	41.6	(20.7)	22.9	(10.0)	35.5	**100.0**	4.9
Population group								
Jews	12.6	26.1	15.3	21.3	21.2	52.6	**100.0**	95.7
Non-Jews	18.6	42.2	22.1	24.7		33.1	**100.0**	4.3
Continent of Birth (Jews)								
Israel — total	12.6	24.6	14.7	21.0	22.5	54.4	**100.0**	73.7
Father Born Israel	14.9	23.5	16.4	19.7	26.2	56.8	**100.0**	12.1
Asia-Africa	14.9	32.2	12.0	18.8	24.1	49.1	**100.0**	14.6
Europe-America	11.4	22.1	15.2	22.3	21.2	55.6	**100.0**	47.0
Asia-Africa	12.7	38.0	14.5	21.1	15.0	40.9	**100.0**	8.6
Europe-America	12.7	27.9	17.9	22.4	18.4	49.6	**100.0**	17.7
Origin[1] (Jews)								
Asia-Africa	14.1	34.3	12.9	19.7	20.8	46.0	**100.0**	23.2
Europe-America	11.7	23.6	15.9	22.4	20.4	54.0	**100.0**	64.7
Matriculation trend								
Humanities, pedagogical, musical, orientalist	15.1	33.1	16.1	21.6	20.1	45.3	**100.0**	49.2
Social	14.1	26.7	(11.4)	19.8	30.0	53.5	**100.0**	9.6
Mathematical-physical	6.6	14.7	18.3	24.3	18.0	61.0	**100.0**	22.5
Biological	9.6	15.6	18.7	23.9	28.1	60.5	**100.0**	14.4
Vocational-agricultural	13.6	22.4	20.8	28.0	(12.0)	49.6	**100.0**	4.3
Field of study								
Humanities	16.8	37.7	14.4	18.3	15.8	44.0	**100.0**	31.5
Social sciences	13.7	27.2	11.9	19.4	31.4	53.4	**100.0**	32.6
Law	(5.3)	(12.0)	(24.2)	25.5	0.0	62.5	**100.0**	2.6
Medicine and para-medical studies		6.3	63.7	63.7	(9.1)	30.0	**100.0**	3.1
Mathematics sciences and agriculture	12.5	23.6	12.3	19.7	27.6	56.6	**100.0**	17.3
Engineering and architecture	5.9	11.4	19.0	25.7		62.9	**100.0**	12.9

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[1] Israel-born were classified according to father's continent of birth.

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NEW CAREER STRATEGIES FOR STUDENTS

Ann Holmes and Esther Levin

Ontario Women's Directorate

SUMMARY: This paper discusses two pilot programs which are initiatives of the Ontario Women's Directorate. Background to the current employment and education situation is presented, along with a description of each program and the evaluation methods for each. Where the evaluation is complete, summary comments and suggested strategies are provided.

BACKGROUND: Inequality between the sexes is an unfortunate fact of the workplace. Ontario women, who work full-time, earn on average 63 per cent of what men earn, and this sizeable wage gap is largely due to occupational segregation in the workforce. While men pursue careers in a wide range of fields, the majority of this province's women — 61 per cent — remain in low-paying traditionally female positions. They work as sales clerks, secretaries, and waitresses for example. This so-called "pink-collar ghetto" has changed little since the 1940s. Yet women have joined the workforce in increasing numbers. In 1960, 31 per cent of Ontario's women worked. Today over 56 per cent of Ontario's women work outside the home, making up 43 per cent of the Ontario workforce. By the year 2000, that figure is expected to reach almost 50 per cent.

A study of enrollment in community college courses reflects the channelling that occurs even before men and women reach the workforce. Statistics in 1982/83 showed that 18 programs offered in Ontario's 22 colleges had a female enrollment of 100 per cent. These courses included early childhood education, the medical secretary program and cosmetic sales. At the same time, 34 programs — most leading to higher-paying careers such as marine engineering -- had all male enrollment. And in many other professionally directed subjects, female presence is slight.

Faced with such disturbing statistics, the role of educators becomes increasingly important. Female students must be made aware of all the career options open to them. Their male counterparts need to be informed about the changing role of women and how such changes will affect their own lives. Along with pursuing a broad based education (that is, continuing with maths and sciences in addition to arts and humanities throughout high school), young women can greatly benefit from role models. These mentors can help to close the gap between female students' aspirations and expectations, providing interpersonal supportive contact. Research indicates that young women who hope to follow non-traditional careers don't know women who are already working in those positions.[1] So it's not surprising that many of these girls consider their aspirations unrealistic.

In an effort to redress the lack of role models for girls and young women, and to encourage these same young women to keep their options open, the Ontario Women's Directorate has spear-headed a number of new initiatives over the last few years. As the central agency in the Ontario government that advocates and supports the development and communication of programs and policies for the women of the province, the Directorate's aim is economic, social and legal equality for women in Ontario. Two school-based intervention initiatives, Open Doors and Pathmakers, are described below.

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[1] Glaze, Avis. *Factors Which Influence Career Choice and Future Orientations of Females: Implications for Career Education.* University of Toronto doctoral thesis, 1979.

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OPEN DOORS: Early in 1984 the Directorate announced the Open Doors program. This program is designed to connect students to women who work in a wide variety of occupations. The pilot initiative was implemented in six Ontario centres. The first task was to identify local women in occupations that rarely attract women, such as construction, engineering, transportation and high technology. Employers and community groups were contacted to nominate women in these and similar fields. This group was then encouraged to join the program and share their experiences with students. A one-day training seminar was offered in each centre. If the women volunteered to be a member of the Speakers Registry, they were listed in the Directorate's central data bank.

The training seminar centered on sharing information and building confidence. At these sessions, women's experience in the workforce were discussed in general terms and print materials were provided for reference. Local educators attended as resource people and they discussed the needs and interests of student audiences. Tips on public speaking were given, and each woman had an opportunity to give a short presentation. The presentations were video-taped and the group offered comments after the instant replay.

In the autumn of 1984, the program went into the schools. It was aimed at the grade 7 and 8 level to meet the Ontario Ministry of Education requirement of 20 hours of guidance class time. The Directorate developed a kit containing background information, resources for teachers and lesson samples. Workshops were held for teachers in the 13 boards in the target centres to introduce them to the program, distribute the resources and encourage them to invite the speakers into their schools.

Open Doors was modified throughout the 85-86 school year. Due to demand, higher and lower grades were included in the target groups and a booklet listing the speakers was published for each pilot centre. Since the program began, Open Doors role models have spoken at career events and participated in panel discussions, as well as discussing in individual classes how they combine their personal and professional lives, and how the school curriculum relates to their occupation. Over 7000 students have been in contact with speakers on a registry which numbers almost 200.

Other school boards around the province have been encouraged to adopt and adapt the Directorate-designed model to meet local needs. For example, an energetic Open Doors model is underway in a northern Ontario community. A need was seen for such a program at the grass-roots level and key interested people volunteered to help get it going. Now there is an active local committee with school board representation, a project co-ordinator and a growing group of enthusiastic volunteers preparing to act as role models for the local students.

PATHMAKERS is another recent initiative also aimed at introducing young women to role models in non-traditional fields. In contrast to Open Doors, the role models in this program are young women who are in post-secondary studies in fields in which women are under-represented. The program is aimed at high school students who will be closer in age to the role models. It was felt that this would help the younger girls identify more easily with the post-secondary students.

This program is a joint venture of the Ontario Women's Directorate, the Ministry of Education and the Ministry of Colleges and Universities. Pathmakers is being piloted in five locations across the province during the 1986/87 school year. Each school board, college and university in the pilot centres was invited by the Ministers of the three partner Ministries to participate in the program. They were also asked to identify people who would be the Directorate's contact people and who would work on the program. These contact people, and any interested role models, formed the local working committees which planned the training sessions for the college and university students and the program activities in the schools.

The participating colleges and universities selected the role models from registration records. Initially there was an information session held in each centre to which the potential role models and the college, university and school board contact people were invited. At this session, further details about the program were provided.

The students interested in being role models attended a one-day training session to help boost their confidence and to provide them with a general background concerning women's experiences in the workforce and the needs and expectations of high school students. Half of the one-day session was spent on developing and practicing presentation skills. The Directorate prepared and distributed a kit of support resource materials.

Pathmakers is presented to each community as a concept - the linking of the high school students with the college and university students in an effort to encourage the younger girls to attain a broad based education and to consider a wide range of career options including fields considered to be non-traditional. This allows each centre to tailor the program to meet their particular needs. This approach means that the role model training programs and the activities in the schools vary from one community or even one board to another. The activities can take form in many ways such as visits to the classrooms by one or more role models, participation as speakers at career days or assemblies, shadowing by high school students of the college or university students as they attend classes, or a joint presentation by a Pathmakers role model and a woman already out working in a non-traditional field.

Because the Ministry of Education as well as the local school boards have been involved in the program from the beginning, and because the actual form of the program is planned by a local working committee, it is anticipated that there will be a strong sense of local ownership which would increase the likelihood of the program being continued and expanded beyond the pilot stage.

Both Open Doors and Pathmakers have been publicized at various provincial teachers' conferences and faculty of education courses. Speeches and workshops have been given with a view to encouraging other communities to model these initiatives and to raise awareness among teachers about occupational issues for their female students. Program co-ordinators at the Ontario Women's Directorate assist in setting up such models by meeting with interested educators and community groups, sharing the experience of the pilot projects and the workshop formats, providing resource kits, recommending audio-visual materials and relevant publications and offering any necessary consultation. Both programs are identified through a communications strategy consisting of letterhead, buttons, balloons and posters (under production) - with the logo "Be all you can do!".

EVALUATION: The Open Doors program was evaluated after two years of operation. Teachers, students, registry members and Ministry of Education officials were surveyed to ascertain the impact and effects of the program and recommend strategies for modification.

Teachers who had used the program were convinced that the students and staff needed to be more exposed to women in non-traditional jobs; and that this might contribute to the elimination of sex-role stereotyping. They said they would encourage others to use the program because of the occupational diversity and quality of speakers on the registry, and because exposing students to the registry was important, positive and worthwhile.

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Most administrators and Ministry officials thought the program was important because it would expand the occupational choices of female students and provide additional information at the very beginning of the career planning process. Most speakers said they had enjoyed their visits to schools and that they had received encouragement and support from their employers.

The Directorate is pleased with the program but is considering the following to increase usage:

1) work more closely with the local community;
2) present a representation of males in non-traditional roles;
3) prepare lesson plans to be available for teachers where possible;
4) consider using videos.

The Pathmakers program is being evaluated currently. The evaluation process will consist of a pre-test and a post-program survey administered to the same random sample from among the role models, the high school students, educators involved in the program and the local working committees. The process will ascertain whether the program has met its stated aims as well as the ease of use and any suggestions for modification in the program.

With these programs the Directorate aims to provide information about career education for female students and to encourage similar activity among students, educators and the wider community. Special initiatives like Open Doors and Pathmakers can help change the traditional patterns of study and occupational selection of our female students.

CAN SMALL CHANGES YIELD BIG RESULTS?

Charlotte Iiams

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The success of past efforts to promote participation of women in science threatens current efforts. Many who should be actively working to further equality of opportunity erroneously believe that the task has been completed, or so nearly completed that other concerns now occupy their attention. In addition to this mood of complacency, there is a backlash against women's rights in the society, evidenced here by the alacrity with which research purporting to show a genetic difference in mathematical ability favoring males was reported in the general press. The concern that the studies did not control for environmental factors received little attention, and research indicating small existing differences were readily overcome by training went unreported. There is, finally, a certain exhaustion among those who have worked so long for programs to promote equality, who have seen major gains made, but have become wearied by continued resistance to finishing the job.

Even organizations and individuals who believe in equity and genuinely desire to be agents in its achievement may find the old ways so ingrained that they overlook policies and actions that could be modified to promote equality. Two years ago, the National Science Teachers Association (NSTA) formed a Task Force for Promoting the Participation of Women in Science. One charge to the task force was to prepare a list of specific actions that the association could take to promote participation of girls and women in science. The list, which follows, includes many suggestions that would be applicable to other organizations and could also be used to address inequitable participation of other minority groups.

Specific Actions NSTA Could Use to Facilitate Successful Participation of Females in Science

I. Encourage members, educators, and the public to recognize that a problem still exists.

  A. Numbers are increasing in some areas, but equity has not been achieved, especially in higher paid positions.

  B. Among young people a gap in performance levels between boys and girls remains and may be increasing. The Minnesota Department of Education reported in 1984 that boys continued to outperform girls at all levels, and the discrepancy at high levels actually increased from previous assessments.

II. Include efforts to promote equity in all appropriate proposals, awards, and actions.

  A. Include promotion of equity as one criterion in each category of the NSTA Search for Excellence Awards and in all awards for science teaching and science programs sponsored by the association.

  B. Encourage National Science Foundation, Department of Education, and Congressional actions to address the equity issue as part of other projects.

    1. All NSF grant guidelines for improvement of science teaching should include promotion of equity as one criterion.

III. Encourage all publishers, media producers, and teachers to integrate (rather than adding on) females in science texts, trade books, and instructional materials.

  A. Use inclusionary, or specifically inclusionary, language and equal representation of males and females in pictures and text. Some publishers who have excellent guidelines occasionally forget to adhere to them, and many media producers and teachers appear unaware of studies on the effects of generic language.

  B. Include social and practical applications of science principles.

The Netherlands PLON project described in *Supplementary Contributions to the Third GASAT Conference*, Chelsea College, University of London, 1985, is an excellent example of this.

C. Use metaphors and examples which appeal to females to supplement traditional bullet, ballistics, and baseball explanations of science principles.

D. Ask reviewers of books and media for NSTA journals to include sex equity as one aspect of the review.

IV. Promote awareness through publications and workshops that teachers who give boys more praise, more approval, more disapproval, and more instruction than girls may be negatively affecting girls' perceived ability to do science. Teachers are usually unaware of this differential interaction.

V. Recognize that failure to provide hands-on experience in early childhood and elementary schools may be even more handicapping to girls than to boys in the development of concrete bases for understanding high school and college science.

A. Extend efforts to help elementary teachers increase knowledge of science and confidence in using hands-on methods for teaching science.

1. The increasing number of elementary presentations at NSTA conventions is noted and commended.
2. Provide a clearinghouse or listing of summer workshop opportunities for elementary teachers in association publications.
3. Encourage universities and school districts to accept lower division course work for lane changes or masters degrees if that work is in an area in which the teacher did not have enough work as an undergraduate to be able to do graduate or upper division work. For example, it is unlikely that an elementary teacher would be prepared to do graduate work in

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chemistry, physics, biology, astronomy, or geology. Yet elementary teachers teach all of these subjects and could use knowledge gained in lower division courses to improve their teaching. Currently, in many universities and school districts, teachers are only able to receive credit toward masters degrees or lane changes for courses taken in education, as education is the only area in which they are prepared to do graduate level work.

B. Publicize texts and successful efforts and methods used by some high school and college teachers to facilitate learning among students with meager backgrounds in science.

VI. Recognize that appearances can lead to sexist consequences even when the substance is quite contrary.

A. Make the equal participation of women in NSTA activities and conventions at all levels more obvious. Equalize the number and size of pictures of men and women in program announcements so readers will form the impression that science at all levels is an appropriate activity for both men and women.

B. Promote the exchange of lists of outstanding women speakers among convention chairs and state presidents to facilitate inclusion of women as major speakers.

Some of these actions, such as changes in the graduate education of elementary teachers, will require sustained effort over a period of years to achieve results. Others, such as including promotion of equity as one criterion in all awards, may be quickly implemented, yet both types of action will move us significantly closer to the desired goal of equity.

EVALUATION OF GIRL-FRIENDLY COURSES OF PHYSICS

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SUMMARY

The MENT[*]-project had developed material for three (small) series of about 10 physics lessons. This teaching material is intended for pupils of the second and third year of secondary schools for general education,(pupils aged 13-15 years). This material is meant to be an example of how to make physics text books more attractive for girls.
Several teachers have now used this MENT-material in the class so a first evaluation is possible.
The results of a formative evaluation are presented. The aim and set-up of a simple effect-measurement is described and some preliminary results of it are given.

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[*] MENT stands for MEisjes = Girls, Natuurkunde = Physics and Techniek = Technology)

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INTRODUCTION

As you know, the number of girls that chose physics as an exam-subject is still significantly smaller than the number of boys.(a.o. Kelly, 1986). For this many courses can be indicated, both inside and outside school (see a.o. Whythe 1986). Causes inside the school that literature pays a great deal of attention to are: the attitude of a teacher towards the pupil, the expectation a teacher has of a pupil, guidance in the choice of profession and exam-subjects and the course-material that is used. Right from the start the MENT -project opted for drawing the attention as much as possible to the aforementioned issue on the one hand, and on the other hand for developing of new course-material.
This new course-material has an example function: we are not concerned with developing one more course of physics but with indicating how it is possible to construct physics courses that are attractive to both boys and girls.

So far 3 courses have been developed:
'Electricity at home', 'Sound', 'Energy and Your body'. It takes about 10 to 15 lessons to deal with one of these courses in class.

In this article you will find a description of the formative evaluation and the set-up of the effect-measurement of the MENT-courses; the article has been structured as follows:

- Structure MENT-course material,
- Formative evaluation,
- Aim and set-up of effect-measuring,
- Preliminary results,
- Conclusions and final effect-measurement.

STRUCTURE MENT-COURSE MATERIAL

Below we present some remarks about the way we have developed course material that is also, or particularly, attractive to girls.
In our society girls and boys are brought up in different ways. That is why a 13-year-old girl will often have other interests and experiences than a 13-year-old boy. There will also be differences in acquired skills and in attitude to and concept of technology (Raat, 1986).
Most physics-courses link up with the 'boys' world'. In the MENT-material we tried to link up with the 'girls' world' as well.

From investigations it appears that girls become more interested and motivated when they learn something about useful and concrete applications (Ormerod, 1973). Besides, it appears that girls, more than boys, are interested in the effects of physics on society and on human beings (Lie and Bryhni, 1983/Hoffmann, 1985/de Leeuw, 1986). Therefore we tried in the MENT-course material to draw a link between the subject physics and the use of it by human beings.

We pay a great deal of attention to things that pupils meet in their own environment (for example a dynamo of a bicycle, a light bulb, a walk-man, musical instruments, nutritional value of food).
Thereby pupils also acquire knowledge that is directly applicable such as to connect a lamp safely.
The impacts on society are discussed in detail. In 'Sound' the subject causing and preventing noise nuisance is dealt with.
Younger pupils (boys and girls) are evidently extremely interested in the way their own body functions (a.o. Whyte, 1986).
For example, the MENT material enables pupils to find out their own breathing frequency, heart-beat, volume of the lungs and to calculate their own power.
To enable the pupils to have their own input as well, particularly with the course 'Energy and Your Body', essays are written.
While writing the courses we took care not to undermine the selfconfidence of girls (and boys) -which is sometimes very little already- sentences like: as you will know ; as you can realize/ understand/ calculate simple;
of course . . . ; as you can deduct/ see easily;
do not occur in the courses.
This to prevent pupils, particularly girls, from being convinced after several negative experiences, of the prejudice that is still often heard, that girls simply cannot do physics.

Not only the interests of boys and girls are different, also the experiences they had in their lives before stepping in to the physics lesson are extremely different. Boys have usually done more technical jobs than girls and they have taken things apart. Therefore girls will be less familiar with a number of instruments, objects and tools than boys are. In the courses we took this into account.
It is necessary that in a coursebook of physics attention is paid to the historical development of physics, which will make it clear to the pupils that physics - by the method of trial and error - has been developed by

human beings. In the MENT-courses some short biographies of physicists have been taken up.
While dealing with the subject-matter it is important to take care that the pupils are not flabbergasted by the abstractions and untransparent formulas.

FORMATIVE EVALUATION

In Spring 1985 teachers were approached and asked whether they wanted to use any MENT-courses at their schools. This resulted in 19 teachers and a total number of 805 pupils using the MENT-courses in the year 1985/86.

For the evaluation by teachers who have used the course an extensive teachers' questionnaire has been designed. In this questionnaire teachers can give their opinion on divergent things such as, for example, the level of difficulty of the assignments, tne number of illustrations, the structure of the course, the extent to which the experiments can be carried out.

After the course had been dealt with in class a questionnaire that contained several questions about the course was presented to the pupils.

The most important results of the formative evaluation are:
- The levels of 'Sound' and 'Energy and Your Body' are adjusted.
- The course 'Sound' has been extended.
- In the course 'Energy and Your Body' the amount of calculating has been reduced and simplified.

Apart from this only small changes have been made in the text and a few illustrations have been added.
With each course there is a multiple choice test. These tests have also been revised on the basis of the results.

AIM AND SET-UP OF EFFECT-MEASURING

AIM

The main aim of the effect-measurement is to answer the following question:

Is the MENT-course material attractive to girls in particular, and if is this to such an extent that it makes the school-subject physics more attractive to girls?

This question has been split up in a number of sub-questions:

1a To what extent to the pupils appreciate the course?
1b Are there any differences between boys and girls in this respect?
2 Does the concept that pupils have of the (school)-subject physics change because of the use of the course?

If question 2 can be answered affirmatively we may go on to the next question:

3 Is there a difference between boys and girls with reference to this change in the concept of physics?

SET-UP

It is the aim of the MENT-courses to show how physical course-material can be made that is attractive to both boys and girls. After all, a lot of existing course-material for physics, and particularly material that is somewhat older, mainly links up with the 'boys' world! In practice it is difficult to measure directly whether the course-material really meets the aforementioned requirement.
We chose a simple effect-measurement in which the opinions of pupils who have used the courses are gauged by means of questionnaires.

Questions 1a/b

'To what extent do the pupils appreciate the course?'
'Are there any differences between boys and girls in this respect?'
After the course had been dealt with six statements, directly relating to the course, were presented to all. They scored on a five-point Likert scale (where 1 means 'totally agree' and 5 means 'totally disagree').
The following six statements were presented to the pupils:

1. I like the illustrations in the course.
2. The text in the course is childish.
3. After the last lessons on electricity (energy, sound), I have more courage to deal with electricity at home (I try to be more economical with energy, I cause less noise nuisance).

4. The past few weeks the physics lessons were quite different from the usual lessons.
5. In the lessons about electricity (energy, sound) I did not learn many new things.
6. In the past few weeks the physics lessons were more difficult than usually.

Table 1 presents the mean scores of girls and boys of the three courses.

	Electricity at home		Sound		Energy and Your Body	
statement	girls n=130	boys n=124	girls n=124	boys n=67	girls n=146	boys n=128
1	2.98	3.11	3.04	3.13	2.88	2.92
2	3.36	2.94*	3.23	3.15	3.51	3.27
3	3.31	3.36	4.15	4.22	3.56	3.46
4	2.86	2.58	2.66	3.27*	2.37	2.28
5	3.36	2.93*	3.05	2.97	3.60	3.64
6	3.84	4.20*	4.23	4.21	3.26	3.51

*means significant difference between boys and girls, $P < 0.005$.

What strikes the attention is that there are few significant differences between the girls and the boys as far as the evaluation of the causes is concerned. With 'Electricity at Home' the girls slightly disagree with statement 5, whereas boys are neutral about this. Both girls and boys think of this course that during the past few weeks the physics lessons were not more difficult then before, however, the girls to a less extent than the boys.

Questions 2 and 3

'Does the concept that pupils have of the (school)-subject physics change because of the use of the course?'
'Is there a difference between boys and girls with reference to this

change in the concept of physics?'
Before and after the discussion of a course the same 15 statements were presented to the pupils. All these questions are related to the way pupils experience the (school-)subject physics and their concept of this subject. Here too the pupils scored on a five-point Likert scale.
By checking whether there are any differences in the (mean) scores it is possible to establish a change in the concept (should there be any).

Preliminary results effect-measuring

The main aim of the first effect-measuring was to test the set-up and the instrument.
During the first effect-measuring the courses were not yet been revised. This, among other things, resulted in the fact that for many pupils the course 'Sound' was somewhat under their level, while on the other hand the level of the course 'Energy and Your Body' was too high for a lot of pupils. It is almost sure that these circumstances strongly influenced the opinions of the pupils on the courses.
The shifts for each course and statement, as calculated in this first effect-measurement, are divergent and difficult to interpret.
Because no clearcut conclusions can be drawn on the results of this first effect-measurement, based on not revised material, we only present here the 15 statements and the mean scores of the girls and the boys before the course was discussed.

Statements

1. Physics is an easy subject.
2. Energy is an interesting phenomenon.
3. I am good at physics.
4. For physics you have to do your homework very well.
5. It is useful for everyone to know something about energy.
6. Physics is a boring subject.
7. For physics I have to work hard to be able to understand it.
8. Physics is more a subject for boys than for girls.
9. Physics is an interesting subject.
10. It is important to know something about the saving of energy.
11. Physics has nothing to do with human beings.
12. Physics is much more difficult for girls than it is for boys.

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13. Later on physics is of less use to girls than it is to boys.
14. At home I do not need to spend much time on physics to be able to pass the tests.
15. I think physics is the subject for me.

Table 2

	Energy and Your Body		Electricity at home		Sound	
statement	girls	boys	girls	boys	girls	boys
1	3.99	3.38	3.96	3.32	3.47	3.10
2	2.07	1.63	2.30	1.90	2.65	2.36
3	3.57	2.85	3.71	2.90	3.60	2.71
4	2.90	3.16	2.75	2.91	3.24	3.21
5	1.92	1.83	1.96	1.75	2.50	2.31
6	3.38	3.62	3.22	3.50	2.90	3.36
7	2.37	2.98	2.28	2.95	2.59	3.40
8	4.24	3.53	3.93	3.63	3.65	3.67
9	2.66	2.26	2.73	2.34	3.43	2.53
10	1.88	1.83	1.66	1.56	2.71	2.60
11	3.82	3.64	3.66	3.74	3.71	3.69
12	4.34	3.80	4.08	3.71	3.80	4.00
13	4.00	3.46	4.38	3.69	3.84	3.57
14	3.83	3.11	3.85	3.31	3.68	3.07
15	3.82	3.20	3.74	3.02	3.36	2.93

Conclusions and final effect-measurement

Three small courses of physics are developed, using criteria for 'girl-friendly' teaching material. These courses are revised, using questionnaires filled in by pupils and teachers. The set-up of the effect-measuring was tested.

The revised courses will be used in the year 1986/87. In summer 1987, on the basis of the data that will be available then, a final effect-measurement will take place, the structure of which will be almost equal the one that is described here.

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GENDER DIFFERENCES IN COMPUTER USE IN CHILDREN OF PRIMARY SCHOOL AGE

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As all participants at this conference will be aware, gender differences in participation in maths, science and technology in general are well documented in the west and occur at all age and educational levels. Such differences also appear to be emerging in those countries in the third world that have been heavily influenced by the British educational system, for example Botswana, Pakistan and Zimbabwe (Siann and Ugwuegbu, in press). With respect to microtechnology, until recently research in Britain has concentrated on pupils of post primary school age, students and adults and the gender gap seems to be established at all these levels with indications that although in recent years more females are actually using computer terminals, and word processors in particular, their use seems to be more routine, less flexible and less autonomous than men's (Gutek and Bikson, 1985). Further there are clear indications that women working at more expert levels experience both implicit and explicit discrimination (Deakin, 1985).

Our research, both in Scotland and in other countries, has been concerned with investigating the extent to which the gender gap in microtechnology exists in the primary school. That it is apparent even at the lower end of the primary school was revealed in a study we conducted in an Edinburgh school. Preliminary work in the school had shown some evidence that using LOGO with 6 year old children had contributed to cognitive change but that this finding held more powerfully for boys than girls (Hughes et al, 1985). Using a subset of the same children six months later, we selected a group of ten using their attendance records as a criterion and assigned them on a random basis to 5 boy-girl dyads for 4 sessions. During these sessions the children performed 4 LOGO tasks using the following procedure. The two children sitting together at the console were first introduced to the particular LOGO task. Then each in turn carried out the task, watched by the other for a period of 5 minutes. They were timed while doing this and their social interaction was monitored throughout to produce profiles. Two of these follow:

COUPLE 1

This couple displayed in general the same level of competence on the tasks they were asked to perform and both showed a fair amount of interest in the tasks. But clear social differences were shown, particularly in the first two sessions, when the girl, although fully as competent as the boy, received and accepted more direction from him than he did from her. For example, from detailed notes 'Sharon continually accepts without any complaint a great deal of pointing and instructing from Brian .... Even when Brian makes an error or looks puzzled, Sharon does not attempt to help'.

COUPLE 4

In general the girl in this dyad appeared less confident at the console than the boy; she was also on the whole rather less interested but if pressed to take an interest her level of competence increased. When it was the girl's turn, her partner in

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all the sessions was inclined to lean over and actually press the keys on the console for her, despite her protests. She, although sufficiently interested in the first session to offer him advice, never pushed any of the console buttons when it was his turn and after the first session displayed very little interest in his performance.

In general, these detailed observations of gender differences over the four sessions of the dyads interacting revealed three tendencies: firstly, the girls on the whole were less interested and motivated than the boys; secondly the girls were more disposed to turn to and seek help from the boys than the reverse; and finally although the girls did seek help from the boys, they resented it when the help was given practically (i.e. by pressing the appropriate keys) rather than verbally. In terms of quantitative differences the boys performed better than the girls but not significantly.

Shortly after this, one of our final year honours students, Anne Knox, replicated this study in Glasgow, obtaining similar results and noting in particular that the boys in her sample were far readier than the girls to profer unsolicited advice. This tendency for boys to be more dominating in the use of computers, in Scotland at any rate, at even the primary school level, has also been commented on by teachers who took part in a survey on teacher's perception of gender differences in the primary school which is mentioned at the end of this paper. Two Scottish teachers, in particular commented that: '.... primary school children are all equally enthusiastic about the computer and the more dominant natures of the boys has to be held in check to give the girls a chance' and 'although interest and ability (in computers) are the same the boys will try to monopolise the computer-likewise many construction toys'.

Our present study using primary school children is concerned with the affect on motivational variables of different types of computer introduction courses. The preliminary data we have analysed so far, concerns questions we asked the children about computers before their formal computer introduction courses and was obtained from a sample of 140 ten year olds (65 girls and 75 boys) with a broad social class spread. Although there is no difference between the sexes in the extent to which they have access to computers at home, or the extent to which they agree that computers are exciting, important and that each class should have its own computer, there are significant differences in the extent to which they report presently using computers ('often': boys 36%, girls 17%; $\chi^2 = 6.1$, $p < .02$), whether they read computer magazines ('yes': boys 51%, girls 25%, $\chi^2 = 8.9$, $p < .01$) and whether or not they attempt to program ('yes': boys 45%, girls 17%, $\chi^2 = 10.6$, $p < .01$).

Furthermore girls seems to be more cautious about their own personal use of computers than boys; for example 84% of boys disagree with the statement that 'computers make me feel nervous', but only 55% of girls disagree $\chi^2 = 12.4$, $p < .01$) and while 51% of boys think they would be good at using computers in later life, only 17% of girls think so ($\chi^2 = 15.9$, $p < .001$). However although girls are more tentative about their own use of computers they are more likely than boys to disagree with the statement that in general boys are better at using computers than girls (girls, 49%, boys, 22%, $\chi^2 = 32.9$, $p < .001$). They are also less likely than boys to agree that in general boys like computers more than girls (57% of girls disagree compared to 13% of boys, $\chi^2 = 15.1$, $p < .001$). Furthermore they are rather more sceptical about computer skills in that 81% of girls compared to 57% of boys disagree with the statement that 'you need to be clever to use computers'($\chi^2 = 8.1$, $p < .01$).

We are also at present collating replies from primary school teachers in 5 countries to questions about gender differences in cognitive abilities. Thus far we have analysed returns from 31 Pakistani and 51 Scottish teachers. On the whole they agree with our sample of girls that there are not likely to be gender differences in the ability to use computers (only 3 of the Pakistani and 2 of the Scottish teachers think boys are better). Nor do any of the Scottish teachers think there are any gender differences in interest while only 7 of the Pakistani teachers think boys are more interested.

We seem here to be faced with something of a contradiction. This is that while Scottish primary school girls rate themselves as as interested in computers as boys do, and while their teachers believe there to be no gender differences in aptitude or interest in computers, when one actually asks how much girls use computers or observes their use, gender differences do seem to emerge (Siann and Macleod, 1986). And certainly overt declarations of interest in computers do show gender differences as girls grow older (Deakin, 1985). Our sample of teachers seemed to acknowledge this for when they were asked about adult interest in computers, 12 of the Pakistani and 18 of the Scottish teachers believed men to be more interested than women.

A study which we have recently completed with 928 students at an institute of higher education (Durndell et al, 1987), seems to throw some light on this paradox. The results of this survey on interest in, attitudes to and experience of computers indicated that on entry to the college, while there were no differences in attitude to technology between the sexes, female students in all faculties had less knowledge of computers, and in all departments except business studies, less experience. Furthermore even within computer science departments females were significantly less likely than males to own their own computers or be knowledgeable about computer games. Indeed our conclusion about the females in the computer science departments was that they were less intrinsically interested in computers than their male peers. We surmised (and are following this up with interviews) that girls were more likely to have chosen this speciality because it made the most appropriate use of their qualifications if they were aiming to make sure of getting a job after leaving college, rather than because they were interested in microtechnology *per se*. The survey, on the whole seemed to point to the conclusion that during their time at college women were able to utilise microtechnology as effectively as males but were more pragmatic about its use, stressing utility more than enjoyment. It seems to us that the roots of this approach can be seen in the primary school where females see themselves as a group as potentially as able as their male peers, value computers equally for what they can do and hold on the whole similar attitudes to technology but are simply less turned on at the personal level. Further where male and female primary school pupils have similar access to computers, males seem to dominate. Whether or not girls resent this domination is a question we now intend to investigate.

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ARE WOMEN ABLE TO CHANGE THE IMAGE AND CONTENT OF SCIENCE AND TECHNOLOGY

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In this paper I would like to make the point that for women to change the image and content of science and technology, it is not enough for them to increase their technical competence, nor it is a question of numbers. What is needed is an increase in their female self-confidence as well, and an intergration of these two. Otherwise we will only proceed in a traditional way. As a case in point I will use the situation in Finland regarding career aspirations among highschool students.

In Finland women and men have an equal role in the working life , but they are working in very different professions. A new Finnish study (Nummenmaa, Vanhalakka-Ruoho, 1985) about young people's choices of professions show that only 25 of the total of 100 girls in the final class of high school (age 18) plan to choose a male profession such as engineering and only 3.4 % of girls aged 15 do the same. The research findings also show that girls even today plan to choose their jobs so that they can combine working life with family life. The girls and boys were asked how they regard their future and more specificallly, how will their life be in the year 2000. Three quarters of the girls describe everyday life in terms of children, home-work and how they will fit their own personal life and work with the daily life of the other family members. The same percentage, i.e. 75 %, of the boys declare that their day will consist of family life and hobbies. However, it has been pointed out that the boys include no descriptions either of home work or how to fit the family life and the working life together in their illustrations.

Since technology has been designed and built up by men, it is very much lacking experiences from the female world. (Ie. there is not 'fit' between the world of technology and the world of women). This may cause the

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fact that women have great difficulties in penetrating into professions within science and technology. One could ask, how have women been at all able to choose such a career? How are women able to combine women's experiences from the female culture with the ways of working and the rules , which are found to be dominating science and technology? How can we make it possible for women to reach a strong female self-confidence and a strong technical self-confidence. Furthermore, how are women able to create out of such a self-confidence an alternative science and technology?

Sex role division in the Finnish labor force

The participation of women in the labor force is high in Finland today. Women formed 48 % of the working population in 1983. The number of female workers has grown in the 1970's, while the proportion of house-wives has decreased. In 1983 only 12 % of women were working part-time (3 % of the men). In 17 % of families having children under the age of 18, the wife was staying at home taking care of the childern. Today 2/3 of the economically active women are working within the fields of administration, book-keeping, office automation, social science, science, and as clerks or artists. The proportion of women grew very much during the first decades of this century. In 1920 women formed 41 % of the labor force, at this level it stayed until 1960. During the 1960-70's the need of labor force grew. During this period the number of women workers increased. The tradition of Finnish women being part of the labor force has attributed to the positive attitude of the Finnish culture to the education of women, and women's work within the field of agriculture. The economic situation of families has supported the women's integration into the working life. As the salaries of men in Finland have not been high, women's wages have been essential for family survival as inflation and the costs of living have increased .

As women and men are equal parts of the labor force in Finland it is interesting to look at the structure of professions. When examining the occupational structure one can even speak of female-dominated and male-dominated occupations. Only about 5 % of the economically active persons are working in fields where there are about an equal number of women and men. These are small occupational fields. Of the labor force 90 % is employed in occupations with a one-sided sexual structure (i.e. 60 % of the persons employed in the field are of the same sex). Female-dominated professions in Finland are: nursing, social service occupations, secretarial and clerical work. Male-dominated professions are: engineering, management, work in the forestry field. Hardly any changes have occurred in these facts during the last decades, although the finnish society has gone through many great changes.

Career choice among Finnish highschool students

Already at an early age children get an idea of which activities are suitable for men and which are suitable for women. The new Finnish study of pupils in general vocational schools showed that the pupils thought most personal qualities and roles could fit both sexes. Still, they thought the tasks of the President were more suitable for men, as they also thougt men better as soldiers and engineers. Women instead, might be better as nurses and cleaning women. The study shows that they have got these opinions while doing different jobs inside and outside their homes. Different Finnish studies also show that at the age of 18-20 most of the boys (ca 40 %) are planning a career within the technical field, while girls at that age are choosing a career within clerical or nursing occupations. These studies have shown that women are more open-minded to choose a profession within a male-dominated field. The female-dominated profession can be seen as an enlargement of the role a wife has in the family. The division of professions according to sex is a phenomenon depending on complicated social, economical, educational and cultural facts. Everyday life and family life also influnce this strong separation. New Finnish research about professional choice, show that only 3.4 % of the girls and 0.7 % of the boys (age 18) plan to choose a profession, that is largely dominated by the opposite sex (by 60-90 %). Instead traditional career choices were very usual, i.e. 57 % of the girls and 67 % of the boys planned a career within a field beeing dominated by their own sex. Girls more often than boys choose non-traditional professions for their sex.

Social factors that influence the career plans

Since the division of professions by sexes is strongly based on historical and cultural conditions, typical female-dominated professions are seen as expansions of the women's family role. Women have moved from the unpaid work in the homes to the fields of nursing, education and service.Those women moving into the labor force have also been taking all the responsibility for the homework. The work of the men have mainly been bound to production and control, to leading and planning the society. The research shows also that the position of the family in society is an important factor when young persons plan their future careers. If the mother in the family has an education higher than average, girls tend to be more unprejudiced in their professional choice. This is also the fact if girls are successful in their studies.

Psychological factors that influence the carrer plans

The Finnish research also show that persons planning a profession dominated by the other sex , have several hobbies, have friends of both sexes, know how the career within the field dominated by the opposite sex look like, have knowledge about the professions and know the profession of their father. They have more and better information about the opposite sex and its world. Girls choosing a male-dominated profession often have activites outside their homes and their fathers take over part of the work at home. I.e. the family has activities turned outside the home. Girls planning their future in an unprejudiced had high demands on their own education, they were also successful in school, had had advanced mathematics and were interested in natural science. The research showed they did less needlework, knitting and home-work than other girls. These girls were more extrovert and more independent in their relation to their parents. These unprejudiced girls notice better the differences between the sexes in different fields of life. They have clearer view of how to combine working life and family life, compared to the girls planning a career within traditionally female professions. These girls have also a picture of themselves that is very similar to the picture the boys have of themselves (as interested in facts, non-religious and rational). If the work of the mother or the educational level of the parents had a remarkable influence upon the professional choice this phenomenon would no longer be rare. Women are nowadays equal in number of the labor force and the educational level of the parents have risen.

Career problems for women in science and technology

The new Finnish study shows that there are many visible and invisible factors influencing women's choice of science and technology as a profession. A partly invisible cultural net has been formed, which makes the choice of the profession dominated by one's own sex easy, at the same time as it is creating several barriers against a career within a field dominated by the opposite sex.

One explanation of the low number of women within technology and some of the fields of science can be explained in the way that there exist "double prefixes" in the world of technology (Walden, 1982). She talks about the male prefix and the technological prefix. The male prefix arose when education in technology from the very beginning had a very strong male dominance. The culture emerging among the students of technology and science is also very strong. It has many features of the habits existing in the male culture. In student jokes and songs one can find many examples of fear of and contempt of women. The male prefix is even strenghtened by the strong tie between the development of technology and the military. The culture of technology is also impressed by control, competition, pointing out the rights of individuals and a strong stress of societal duty. The female culture pointing out the importance of human relations and the responsibility of everyday life has not yet been able to reach the world of technology and science.

The technolocical prefix gives also technology special features. In technical education the process of learning is sequential, i.e. one is learning step by step. In humanistic fields, on the other hand, the learning process is concentric, i.e. one is attacking the problem from different points of view. Persons of special talents choose technology and science, usually persons having convergent ability, they try to find one solution for their problems. A Norweigian study (Thagaard, 1972) shows that women and men choosing the same profession show more similarities, than the sexes within different professional fields. As the interest of the technical field in Finland is very different among the women and men, and as the professions are sharply divided into female-dominated and male-dominated areas and have been in that way during the period 1950-80, there will hardly be a change within the next years. As the Finnish study points out that girls planning a career within science and technology have a similar picture of themselves as the boys of their age plannning a similar career., it is very hard to see how women could be able to change the image and contents of science and technology. In Finland girls pass into the male-dominated professions as they choose an academic education. The number of the persons getting academic education is only 1/10 of each generation. Althoughthe women could achieve high positions this fact has a very little influence, on women's possibilities to introduce new aspects and rules into the technical and scientifical world. There must be structural changes as well as changes in number (Wagner,1986). Women and men must be equally represented in all occupational layers of an institution. Only, when there are sufficient women at different levels of technology and science will they be able to bring their experiences into the world of science and technology.

Some suggestions for change

Women must have knowledge about science and technology when they plan to choose a career within these fields. For the number of women working in science and technology to increase, the knowledge of these subjects must be introduced in a proper way at an early age. I suggest that these subjects ought to be taught in kindergarten, but not in an abstract way, rather

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describing daily life phenomenon as a part of technology. Examples should be taken from the interests of both girls and boys. This teaching should be continued in the primary school. Today, in Finland girls are taught how to knit and use the needle and boys are taught woodwork at the primary school level. These subjects should be obligatory for both girls and boys. I think it would diminsh some of the myths of what is suitable for women and men.

The the Finnish study emphasizes that those girls planning a career within the field of technology need to be supported. Therefore, the teachers should be informed about this fact, and they ought to get advise how to support the girls. At higher educational levels networks or discussion groups for girls could be formed. These groups could be a place where girls could talk about their problems and they could get the right information about working life and studies. In Finland there are today many informal networks for men, men usually get aquainted to some network at a very early age.

The maternal leave is in Finland today 258 working days. At this time the mother will have 80 % of her salary paid by the national health insurance. Today parents can share the parental leave so that the father of the child can take as paternal leave 100 of these 258 days. Very few men use this opportunity to stay at home with their child. Therefore I suggest that the parental leave must be shared equally between the mother and the father of the child. The mother stays at home with the child for the first six months and then the father stays at home and takes care of the family for six months. Today it is very hard for young women to get a permanent job as the employers are afraid they will bear a child, and stay at home for almost a year. If it should be obligatory for both men and women to stay at home with their children, then it would be an equal risk for the employers to employ young women and men of all ages. This would diminsh the discrimination of women having an academic degree, and in that way help the women working within the fields of technology and science.

The Finnish study pointed out that the girls' plans and thoughts about their future life in the year 2000 included stories how to be able to combine working life with family life and childcare. The boys of the same age described what their working day looked like and how their spent their time with their family. As the girls have a more realistic vision of their life in the year 2000 than the boys, it is hard to change the traditional way of choosing a career. Today it is not enough to inform the girls and aquaint them with the world of technology and science, in order to increase the number of women working within these fields. For people to choose their careers in a more open-minded way family and cultural education must be expanded at the same time.

When we have reached such a state, women could perhaps get a good self-confidence and a good technical confidence. Then it might be possible for women to develop an alternative technology and science.

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WOMEN IN THE FIELD OF ENVIRONMENTAL PROTECTION IN CHINA

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Everybody living in the world has an inherent right to enjoy pure and clean air and water and soil, a uncontaminated beautiful environment. Some eight thousand years ago, the environment was natural and clean, but people had to wandered in search of whatever food nature might provide. The discovery that food could be produced, either by cultivating plants or by taming animals, changed man's entire way of life and started the course of civilization of mankind. The development of energy source used by man is a good example of the development of the whole world. In ancient time, all work was performed by muscle power. In the second century B.C., man found that much muscle power could be replaced by natural forces. Around the tenth century B.C., man invented water-driven machines. Near the end of eighteenth century, fossil fuel (coal) was used by man to heat water to steam and then the steam was forced under pressure to drive pistons of work engines. In the nineteenth century, oil and natural gas were added to the list of energy-producing fuel. By the end of nineteenth century, man developed eletrical energy from water or heat power. Finally, in the twentieth century, man found a new and tremendous power source, nuclear energy. As a result of fresh scientific knowledge with its technological consequences and their utilization by industry, man strode from discovery to discovery, from invention to invention, at a consistent and ever-quickening pace. That development has brought us to the situation as it exists today. We now have much more foods and material goods, much better living conditions and services than our ancestors. But at the same time, the environment we live in is much worse than before. The earth now is crowded with people, and all of them consume resources and creat wastes during their living and industrial and agricultural activities. We have reached the point in environmental pollution where nature can no longer yield all that is desired. Environmental pollution is related to the number of people, many natural phenomena, such as forest fires, collapsing river banks, and volcanic eruptions, but the industrial potential for pollution merits more attention. To protect air, water, and soil from all kinds of pollutants, to maintain a environment which is no harm effects to people, have become a grave responsibility of the present generation.

China is facing very arduous task of pollution control. Because it has very large population, it's industrization is rapidly carried out and it is short of funds for everything should be done, the pollution of water, air and soil in China is tremendous serious. Many rivers and lakes are contaminated by heavy metals, toxic chemicals, organic pollutants and nutrients. The emission of carbon monoxide, sulfur oxides, hydrocarbons, nitrogen oxides and particles have caused adverse effects to the health of people. The unsatisfactory disposal of solid wastes not only occupy but also diminish the value of land. People become more and more concern with the quality of environment in China.

Based on the experiences and lessons at home and abroad, the government of China has declared that to protect environment is a basic national policy. The first and the second national conference on environmental protection held in 1973 and 1983 respectively have adoped and revised a principle of simultaneous development of economic construction and environmental protection. It means that the design, constrution and opening of the environmental protection measure should be completed at tha same time as the industrial establishments. A serious of laws and regulations on environmental protection have been issued. Environmental standards and discharge limits for protecting air, water and soil have been established, Hundred of monitoring station have been set up in cities and enterprises. Research projects on pollution control and environmental protection are carried on extensively and profoundly. Environmental eduation has been recognized as a very importment topic both in universal eduation and specialized eduation. Management authorities of environmental protection have been set up from the central th local government. Investment in environmental protection is increasing from year to year. All these efforts has been proved efficacious. It was reported that about 100000 of projects for controlling pollution have been constructed during 1980 to 1983 and 70% of them are in good use now. Compared to the output in 1980, the output in 1983 increased by 24%, while the industrial solid wastes decreased by 12% and the pollutants expelled decreased by 15% and the heavy metals, oil and toxic chemicals in wastewater discharged from industries decreased by 70%, 41%, and 62% respectively. The number of cities and towns which have water supply service has increased from 72 in 1949 to 253 in 1981, and the number of water purication plant from 120 to 660. To the end of 1983, the number of cities and towns with drainage system has reached to 252. Municipal wastewater treatment plants are being built in many cities. Tianjin municipal sewage treatment plant, with the capacity of 260,000 cubic meter per day, has gone into operation in 1984. Non-waste technology and production has been developed rapidly in all kinds of industries. It results the saving of energy and raw materials, the reduce of waste gas, waste water and waste solids. In short, we are making great progress in protecting environment but we still has a long way to go for solving the pollution problem caused by the development of industrization and large population.

As a professor in environmental engineering, I would like to briefly introduce the scientific research and education on environmental protection in China. There are 138 research institutes on environment science or environment engineering in China in which up to 5000 special personnel are conducting research project on both applied technologies and fundamental theories. It was estimated that more than 2000 research projects have been completed and which has obviously promoted the development of the course of environmental protection in China. There are 64 colleges and universities and 18 technical schools have set up the speciality and research institute on environmental science or environmental engineering. About 500 post graduates, 1800 university students and 2600 polytechnical school students are studying on environmental protection scientific knowledges and technical skills for preparing working for the cause of environmental protection. In order to raise the professional level of environmental protection authorities, different types of short courses have been held by the National EPA and the authorities of provinces, cities and twons, 25,400 in service managerial and technical personnel have received trainning in rotation. Chinese Society of Environmental Sciences (CSES), an academic mass organization (non-governmental) organized voluntarily by the scientific and technological workers in environmental field. All of the people with the title of professor, engineer, agronomist, doctor, economist, assistant research fellow and lawyer involving in the field of environmental sciences could apply and be society members. CSES has more 20000 members up to now.

As a woman who works in the field of envieonmental protection, I am very proud of the significant role of women and girls in the undertaking of environmental protection in China. It is roughly estimated that women and girls constitute one third of the total amount of scientists, engineers, teachers, technicians, and workers in the field of environmental protection in China. They have made positive contributions which can't be neglected and some of them are in very high position. As far as I know, the chief of the EPA in Beijing Municipality is a woman named Jiang Xiao-ke. Professor Wu peng-min, a famous chemist, is now leading the Beijing Municipal Environmental Monitoring Center. Another women chemist named Liu Jin-yi is the director of the Institute of Environmental Chemitry, the Science Academy of China. The deputy directors of the EPA in Shang-dong province, Gan-su province and in Tie-jin city are also women. They have shown extreme warmheartedness towards their work, outstanding abilities in scientific research and management of an institute as well. The deep love of a woman to her parents, spouse, and children has expanded to the deep love to all the people and to the dedp care to the environment in which people live. It should be pointed out that the special characteristics of a woman, such as abundent and easily excited emotion, steadfast to her principles, persevering in her undertaking, attentive to work and people,and devotion herself to her family and society, etc. are of very importment significance for a worker on environmental protection.

At the end of my speech, I would like to say a few words on the University and the Department I am working in and my collegues, my students, and myself. Tsinghua University is a comprehensive University which consists of five colleges and more than fifty speciaties. There about 11,000 undergraduate students and 3,000 post graduates. The Department of Environmental Engineering is one of the youngest departments in the University. There are 300 undergraduates and 80 post graduates in the department. Girl students constitute one third of the total amount of students in the Department of Environmental Engineering while constitute one fifth on the University. It is another proven of the deep care to environment which hold by women and girls. In the Department, there are women professor, associate professors, lecturers, engineers, and research assistants. All of them are working enthusiasticly and cooperating quite well with men collegues. I am teaching the course of Biological Treatment of Wastewater, the Control of Water Pollution of Industries and conducting research projects on anaerobic biological treatment processes and wastewater stabilization pond. Eight post graduates are studying and doing research work under my direction, haly of them are girls. It seems that girl students are fond of me and I am fond of girl students. It is undoubte to me that women and girls can do everything which do by men in the field of environmental protection. Women and girls have made great contribution to the cause of environmental protection in China, and will make greater contribution. I would like to devote myself to a clean, beautiful environment in which we are living.

The history of science and of women scientists - What can it tell us about our relations to science today?

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Abstract

Universities and science are now formally open to women but there are still not many women scientists and girls do not seem to see science as something important to them. It is essential to discuss what factors influence our choice of education and to see that this choice can be forced upon us by society and school. A very fruitful starting point for such a discussion is women scientists in history.

In this paper I point out that the idea prevailing during the scientific revolution that science is an objective, rational enterprise and women are subjective, irrational and presumably not suited for science may still exist.

The lives of Mary Somerville and Lise Meitner are described and form the starting point for some comments and questions about our relations to science today.

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Introduction

Universities and science are now formally open to women but there are still not many women scientists. Why is it so?

One could expect that girls do not know where the future well-payed jobs are and therefore do not choose to study science and technology, but I do not think this is correct. Girls have a fairly good knowledge of the world. They know what science looks like in school and they know that in the future they are expected to take responsibility for children, family, parents and for relations between people in private, on the labour-market and in politics. They have to choose an education with this in mind and they cannot see science as something important for this activity. Girls scarcely know of any women scientist and their teachers, parents and friends do not expect them to be good at science. Science in their opinion leads to nuclear reactors, the arms race and to trips to the moon, all unimportant for the survival of mankind, so why should they bother about science, especially when teachers and the labour market do not seem to think high of women in science. That they do not choose science is however not often a quite concious choice and they may later in life regret that they dropped science in school. It would be desirable that if girls drop science in school it should be a deliberate choice.

It is essential to discuss what factors influence our choice of education and to see that this choice can be forced upon us by society and school. A very fruitful starting point for such a discussion is women scientists in history. That activities of women scientists in history were restricted by the ideas about women of that time is often obvious and by comparison with our own time one can see that many ideas have survived and still influence us even if they are not so clearly outspoken. It is also very stimulating for a girl interested in science to see that other women have been very interested in science and also successful as scientists. We will therefore try to collect information about women scientists in history and to discuss the conditions of today in the light of history. We also intend to distribute this information in an easily comprehensible form. In this paper I shall try to give a few short examples of our ideas.

The image of women during the scientific revolution

During the scientific revolution one wanted to sweep away predjudice and superstition and instead seek knowledge through rational experiments and methods. The Aristotelian philosophy of nature was criticized but his ideas about women nature were left uncontradicted.

The world is often described in dualistic terms:

subjective	objective
irrational	rational
passive	active
under	over
weak	strong
emotion	reason
nature	culture

It was clear to the seventeenth century scientist that science was described by words in the right column. We could also add male to the right column and female to the left. So it was clear that women nature was not suited for scientific endeavour. One of the "fathers" of science, Francis Bacon, welcomed the truly masculine birth of time when man through knowledge will get power over the female nature.

If today we have to add female to one column and male to the other we can very easily do that. We still have the same characteristics of male and female, and of science too. Science is an objective, rational enterprise ---- so, women are presumably not suited for science.

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Mary Somerville, the Queen of the Nineteenth Century Science, who believed she had no scientific genius.

The life of Mary Somerville is described by Lynn M. Osen (1974) and by Margaret Alic (1986).

Mary Somerville was born in Scotland in 1780. She got only a rudimentary formal education but she was very interested in mathematical puzzles in women's journals. She had never heard of algebra and wondered what the x's and y's meant. It seemed so interesting to her. She succeded to obtain a copy of Euclid's Elements of Geometry, but her parents removed her candles so that she could not read at night. Then she memorized the books and worked out problems in her head at night.

Mary was married and got two children but her husband soon died and left her a widow. Now she was free to pursue her own interests. She won a medal for her solution to a mathematical problem. She married again to a man who shared her interests and supported her scientific work. She translated and explained Laplace's "Méchanique Célèste". Her "Mechanisms of the Heavens" remained a standard text in higher mathematics and astronomy for the rest of the century. She also wrote "The Connection of the Physical Sciences", a summary of research in physical phenomena, and when she was eighty-nine years old her "Molecular and Microscopic Science" was published. It was a summary of the most recent discoveries in chemistry and physics. Mary Sommerville was called the Queen of the Nineteenth Century Science.

Mary Sommerville started her scientific work when she was middle-aged. What might she have done with early encouragement and training? Despite her success Mary thought like others at that time that women were not really aimed for science. She said "I have perserverance and intelligence but no genius, that spark from heaven is not granted to the sex, we are of the earth, earthy, whether higher powers may be allotted to us in another existence God knows, original genius in science is hopeless in this." (Alic, 1986 p 185)

What do we in general think today? The example of Mary Sommerville shows, I think, that women are suited for science, but we do not always realize it because of the prevailing image of women.

Lise Meitner, a nuclear physicist who did not want to work for the nuclear bomb

Lise Meitner was born in Vienna in 1878. Her father was a lawyer of Jewish origin. Lise was early interested in mathematics and physics. However, before she was allowed to study science she had to pass the state examination in French so that she might support herself as a teacher of French (Frisch, 1970). She entered the University of Vienna in 1901 where she obtained a doctorate in physics in 1905.

After her doctors degree Lise Meitner did an independent work in optics and got it published. That gave her courage to ask her parents to allow her to go to Berlin for a few terms. She in fact stayed there for thirty-one years. When Lise arrived at Berlin in 1907 she knew nothing of German universities. She only knew the name of the famous theoretical physicist Max Planck who had visited Vienna. When Lise registered at the university of Berlin to attend Planck's lectures, he received her very kindly, but he also asked her "But you are a Doctor already! What more do you want?" A woman who wanted to do research seemed peculiar to him. In an enquiry about academic studies for women in 1897 he answered that it had not been acute in theoretical physics. If a woman, which sometimes happens has a special talent for theoretical physics and a liking to develop it, it would be wrong to prevent her from studying by principal reasons. But this can only be exceptions. In general one has to stress the role of mother and housewife which has been given to her by Nature, he said (Krafft, 1978). Planck must soon have seen that Lise Meitner was such an exception as he gave her a job as Assistant between the years 1912 and 1915, a fact that gave her some respect among other physicists.

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In Berlin, Lise Meitner also met a chemist, Otto Hahn, who was looking for a physicist to help him with his work in radioactivity. Lise had already worked in this field in Vienna and she felt that she could learn a great deal from the work with Hahn. The difficulty was that Hahn worked at the Chemical Institute under Emil Fischer, who did not allow women in his laboratory. So Hahn and Meitner had to equip a carpenter's workshop for their radiation measurements. Two years later, in 1909, when women were admitted to academic studies in Germany, Emil Fischer let her in and supported her, too.

Otto Hahn, the chemist, was most interested in the discovery of new elements and the study of their properties. Lise Meitner was more interested in their radiations. She studied for example the energies of β-rays. The war (1914-1918) interrupted their work. Lise became an X-ray technian in the Austrian army. After the war they continued their work. In 1919 the University of Berlin gave Lise Meitner the title of professor, but she did not get the right to lecture until 1922.

In the early 1930's Enrico Fermi in Italy bombarded uranium with neutrons and got at least four radioactive substances. Could some of them be transuranic? Hahn and Meitner and a young chemist Strassmann tried to check Fermi's results. From Joliot-Curie in Paris came the surprising result that elements below uranium in the periodic table were produced in this reaction.

At this time, in 1938, Lise Meitner because of her Jewish origin was threatened in Nazi-Germany. Her application for a visa was refused, since Himmler had ordered scientists, whether Jews or not, not to leave the country. A Dutch colleague then smuggled her into Holland and via Copenhagen she came to Stockholm, Sweden.

Before Christmas 1938 Lise Meitner in Sweden got a letter from Otto Hahn, where he told her, that he and Strassmann after experiments had concluded that barium was formed from the uranium nucleus, when it was bombarded with neutrons. Lise and her niece Otto Frisch discussed this at Christmas 1938 and found out how this could happen. The uranium nucleus must have undergone fission. At fission energy is released. The physicists soon realized that a chain reaction releasing lots of energy would be possible. The nuclear bomb could be a possibility. In contrast to many of her male colleagues Lise Meitner did not participate in the work on the nuclear bomb and she hoped that the project would prove impossible.

Prices, academic memberships, and honorary doctorates meant little to Lise Meitner and she disliked publicity. She wanted to understand better what matter is made of, with no thought of gain or fame (Frisch, 1978).

What can we learn from the lives of these women scientists?

In spite of the great difficulties women scientists met in trying to get admission to scientific education, a few succeded and got famous scientists.

Mary Sommerfeld thought that women were not really aimed for science. Lise Meitner met persons who doubted that women could and should be scientists. What is the opinion about women today? In Sweden the official policy is to encourage girls to study science and technology, but behind the official words old ideas about women may lurk giving girls a schizophrenic message.

Lise Meitner did not want to work with the nuclear bomb. Most male physicists did. Women seem to be more concerned about the consequences of science than men in general. Girls may reject physics because of the near relationship between physics and arms industry or at least they feel uncomfortable over it. This rejection has to be met with a serious discussion. Is there a possibility to change the use and abuse of physics, if more women engage in the subject?

In scientific work it is essential to be first and to communicate the news to colleagues and to the world. The person who is second is not given any credit. This does encourage competition and discourage cooperation. Prices, publicity, and career meant little to Lise Meitner. Is career less important for

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women? What consequences does this have for the possibility for women to be successful in science?

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Changing the Image of Science: The Contribution of Women Scientists.

Anne Walton

Summary.

The myth of 'objective' science is examined and, in part, refuted. The traditional image of the scientist is in some measure responsible for young people's rejection of science.Two types of scientist can be identified; those who conform to the traditional image (category 'A') and the nonconformists (category 'B'). Women scientists tend to be the latter, as is indicated by the human-oriented nature of their work. These women, and their work, should be better known because they are potentially excellent role models for girls.

> 'The scientist should never make pontifical announcements ...'
>
> (Lampkin, 1938)

Mitroff (1974), in his fascinating study of the Apollo moon scientists, describes what he calls the 'Storybook Image of Science'. He asserts that it is 'an image of science that is encountered in textbooks and in popular accounts of science too frequently to be dismissed' and that the 'Storybook view' has been held by 'many intelligent and otherwise discerning men of importance and influence.' The chief tenets of this view are emotional neutrality or even the absence of emotion, for example the 'renunciation of emotion' (Lampkin, 1938) and the 'readiness to think coldly' (Ebel, 1938), an objective attitude .... and so on. Mitroff's contention is

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that 'for too long one of the myths we have lived with is that science is a passionless enterprise performed by passionless men, and that it *has* to be if it is to be objective. What this myth ignores is that many of the great scientific achievements of the past have been the result of passionate, if not outright biased, inquiries' (Mitroff, 1974).

It seems undeniable that the 'Storybook image' has persisted and has been propagated throughout our educational systems. 'The stereotype of the emotionally reticent male, unworldly, somewhat unsociable, more interested in things than people, holds throughout the student population' (Head, 1985). One of the problems identified in the Girls Into Science and Technology (GIST) project (Whyte, 1986) was the alienation felt by girls towards the masculine image of science. The notion of the 'typical scientist' as male, 'independent, rather cold, single-minded in his work, interested in things rather than people, avoiding complex human emotions, a 'stander-back' from social relationships and encounters' is 'dramatically opposed to the stereotype of the way women in Western society are expected to behave'.

Moreover, scientists themselves must take a large share of the blame for perpetuating this image. Most of us who are, or have been, practising scientists were raised on the myth of objectivity and, at least part of the time, believed ourselves to be detached and devoid of emotion, where our scientific endeavours were concerned. There is, undoubtedly, a substantial core of scientists who *still* believe it, in spite of abundant evidence to the contrary.

It has been suggested (Head, 1985) that some boys (but probably few girls) actually find this image attractive, and choose to enter a scientific profession because they believe that it is impersonal. This can be dangerous because as Facey (1986) points out 'The man attracted into science because he dislikes 'people problems' may wish to behave ethically, but will not want the involvement with people which thinking about responsibility entails. He will prefer the ethics of the abstract principle. The ability of some scientists, at least for a limited period, to focus on their scientific activities while being unable or unwilling to see them in a wider social and human context, is exemplified in the research on nuclear weapons, the unjustifiable use of laboratory animals (to produce yet another shampoo) and the irresponsible management of some chemical plants.

Socially aware students, of whom the majority tend to be girls, frequently do not opt for this kind of science and may find the physical science courses which they are expected to do at school 'dehumanized' (Pawlyn and Allsop, 1986) and having no apparent relationship to the 'real-life problems they think are important' (Perry, 1986).

Thus, there are several matters demanding our attention. First, there is the 'hard-core' of male scientists who conform to the traditional image which I shall call category 'A'. In order to reduce their influence, either their attitudes need to be changed, or we must try to ensure that young people entering the profession no longer do so for the 'wrong' reasons and become category 'A' scientists themselves. Second, we need to publicise the attitudes and work of male scientists who do not conform to the traditional pattern (category 'B') so that the image which we pass on to our students is a more accurate one. The third problem is the invisibility of women scientists, many of whom are also category 'B' and do the kind of work which would appeal to girls. The fourth is that so few girls choose to study the physical sciences. If we can deal successfully with problems two and three, this may help us with problem four.

It is interesting that the 'Storybook view' of science and scientists is so dominant that the alternative views of the nonconformist category 'B' scientists (some men and most women), are relatively unknown, although they are readily available in the literature.

Many scientists have written about the aesthetic aspects of science. Watson, in his far from objective book, *The Double Helix*, (Watson, 1968)

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says it was 'too pretty not to be true'. One of my teachers used to speak of an experiment being 'elegant'. Pauling and Hayward (1964) combined science and art in the *Architecture of Molecules* as did Stevens (1976) in *Patterns in Nature* and Buckminster Fuller in his architectural designs. I remember my own deep intellectual and aesthetic satisfaction when I used the concept of structures formed from linked polyhedra in designing and constructing models of zeolite crystals.

Imagination, intuition and insight are fundamental components in scientific discovery. Most people know the story of Kekule's atoms dancing in a ring. The mathematician, Poincare (Vernon, 1970) had a similar experience when stepping on to a bus. 'The idea came to me, without anything in my former thoughts seeming to have paved the way for it ... ' After that, all he had to do was prove it - which he successfully did! Knowledge and thought can take you *to* the barrier; only a leap in the dark can take you over it. 'There we reach the great barrier of thought because we begin to struggle with the concepts of time and space before they existed in terms of our everyday experience. I feel as though I've suddenly driven into a great fog barrier where the familiar world has disappeared' (Sir Bernard Lovell, quoted in Capra, 1975).

Most scientific work, however, is not so rarified. Rather, it is very much down to earth and dealing with everyday matters. The scientist, far from being isolated and aloof, is most likely to be working with a team of people, perhaps each one working on some aspect of the same problem, or on different problems but in the same laboratory. There may be a professor or director in charge and junior people will receive guidance from him (or in quite exeptional circumstances, her) and other experienced people, but *primarily*, they will learn from each other. If one aquires a skill (glass-blowing for example, or how to handle a new piece of equipment), s(he) will teach the others. In all but the largest laboratories (unusual these days), each will know what the others are doing and they will have endless discussions - about their work, and about everything else. An integral part of the majority of laboratories is the 'tea-room', sometimes dignified (and legitimised) by being called a seminar room. Here one can 'brew-up' any time of the day or night, and it is here that problems tend to get sorted out. Not uncommonly, it is shared by all staff, technicians, secretaries, visiting professors, gardeners and maintenance men, and thus helps to engender a corporate spirit, and mutual respect, among those working together. Recently, Sir Nevill Mott was interviewed about the time he spent working with Niels Bohr (Mott, 1986). He said 'The subject, as I had learned, could be a social activity, built on discussions and the exchange of ideas, and so the tea and coffee room would be the center of our activities.'He also says he learned 'how beautiful physics could be'!

Many girls who are good at, and enjoy science at school, are conscious of a desire to work with, and for, people and, in a direct and obvious way, to satisfy their youthful idealism. They may choose to study medicine or related disciplines.

However, I believe that some young women, like some young men, are curious about the natural world and natural phenomena, and that what one might call at this stage an abstract interest, may lead them to choose to study science. It is also possible that the apparent rigour of the approach to the subject and the systematisation of scientific knowledge may seem to compare favourably with the manifestly more subjective treatment of arts subjects. At least superficially, these young women seem to embark on a scientific career on the same terms, accepting the same mores and with similar expectations of what a career in science entails, as young men. Indeed, one may ask whether they would ever be considered suitable for a scientific career if they did *not* conform in this way.

A small minority of women specifically choose careers in the 'hard-core' physical sciences. Many of these are highly intelligent 'all-rounders' who could have chosen to study virtually any subject. For them the physical sciences are an intellectual challenge; a caucus of knowledge which would be denied to them without formal training. They tend to begin their careers in the main-stream of physical science but, in a large number of cases, as their careers progress, there is a change in the nature of their work towards more obviously human-oriented projects, most commonly medical, biochemical or pharmaceutical but also in pollution control and other environmental matters, food science and so on. (Many more examples may be found in the Short Reading List given below.) The change of direction may be a conscious choice or attributable to other factors.

Janet Vaughan, former Principal of Somerville College, Oxford, a physician and medical researcher, said 'Always throughout my working life there have been these two, sometimes conflicting, forces: the desire to help redress the ills of society, and the desire to help push forward the frontiers of scientific knowledge' (Caldicott, 1984). This, surely, is a dilemma which many must have confronted.

I would not for one moment suggest that there are no men who go through what I now see as a maturation process (and I do not mean this disparagingly, having experienced it myself), but it does seem to be a *characteristic* of women scientists.

It is tempting to attribute this phenomenom to the early differences in socialisation experienced by girls and boys. If, as is often claimed, girls are raised to be carers and boys to be achievers, then a typical category 'A' scientist will be primarily an achiever while a category 'B' woman or man will be an achiever *and* a carer.

Recent work on the psychology of women (see, for example, Gilligan, 1982) has suggested that women *do* have a different view of the world from men; one that has been described as more holistic, in the sense of allowing for a wide range of possibilities, making connections, interdependence, and interaction, rather than control and dominance (Keller, 1983,1985, 1986; Kolbert, 1985). While the holistic approach seems to come naturally to many women, one could argue that it is precisely this ability to bring together a variety of apparently unrelated pieces of information which provides the insight leading to great discoveries - most of which, so far, have been made by men!

However one may speculate about the reasons, the fact is that a high proportion of mature, established, female scientists are doing the kind of work which girls can clearly recognise as being for the good of humanity. They are, therefore, excellent role models and much more attention should be paid to them and their achievements.

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FACTORS AFFECTING THE ACHIEVEMENT OF WOMEN AND GIRLS IN SCIENTIFIC ENDEAVOR

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INTRODUCTION

Within the last one decade, special attention has been focused on the role of women in development. This has been necessitated by changes in the social and economic conditions the world over. One of such changes is the modification or complete round-about turn in the view of those who see women mainly as consumers with little or nothing to contribute to development.

Evidence abound to show that women, from time past, have always participated in the social, political and economic development of most nations. The problem, however, has been that their contributions were never documented and acknowledged. Furthermore, they suffer the backwash effects of development programmes. They therefore do not benefit as much as the men in various development programmes. All these have made the women, especially the rural women, to be more of a marginalized group (Williams, 1978[1] and Oyatoye, 1984[2]).

According to Okojie (1985)[3], women can be integrated into development process in two main ways, namely as participants and/or as beneficiaries of development, both of which are inter-related. Participation in development can be either in the economic, political or social spheres. Women can be beneficiaries of development if they are active participants in the development process in the economic and social spheres. They also benefit socially through greater access to education, employment, improved social services such as health and housing, and improved technology. Women can therefore be producers and consumers of fruits of development.

The purpose of this paper therefore is to examine the extent to which women living in rural parts of Nigeria adopted a variety of technologies introduced to them. The factors which influenced their adoption behaviour in each case are also discussed.

METHODOLOGY

This paper relies very heavily on the annual reports of the Isoya Rural Development Project (IRDP) of which the author is a member as well as reports of some experiments conducted by Patricia A. Ladipo also within the IRDP.[4]

The Isoya Rural Development Project (IRDP) was started in 1969 by the University of Ife as a pilot project in integrated rural development. That is, in addition to the objective of improving the living conditions of rural people in the area around the University, the project was meant to serve as a laboratory for testing and teaching approaches to rural development. Because experimentation was built into the project, programming was flexible, and it was possible to modify projects even after they have taken off.

The project includes programmes in agriculture, intermediate technology, nutrition, use of loans, family planning, medicare, and development of cooperatives. This paper summarizes the adoption behaviours of women in those technologies which were directed at them.

FINDINGS

Project 1: Developing Women's Co-operatives in Rural Nigeria

i. This experiment reports the performances of two groups of Yoruba women who tried to organize themselves along the lines of multi-purpose cooperatives.

ii. This type of institution was originally found among men designed to take care of the interest of farmers growing export crops such as cocoa, oil palm and kernel etc.

iii. The major interest was to find out whether there was difference in performance between the two groups --- one designed to adhere to government regulations for co-operative formation; and the other allowed to adapt these regulations or evolve its own regulations.

iv. The study showed that the group which was allowed to evolve its own regulations performed better economically and socially. Cohesion, personal development and financial growth were found to be greater in the self-regulating group.

The implication of these findings is the need for modifications in government requirements for co-operative development.

Project 2: Family Planning

i. The purpose of this experiment was to explore whether women in rural Nigeria were changing their perceptions of their maternal roles; whether there was a growing tendency to want to limit family size, and to determine factors associated with these changes, if any.

ii. Data for the study were collected by interviewing cooperative members singly in private and in local language (Yoruba) using interview schedule. Interviews were conducted by a university student and by a project (IRDP) staff both of whom were well liked by the women. Interviews were first recorded on tape and later transmitted verbatim so that the women's feelings would not be lost in translation prior to analysis. The interview schedule was developed by the researcher (Patricia Ladipo) by (a) discussing concepts of motherhood, fertility, infertility, and birth control with traditional healers; (b) testing and modifying sections of the focused biography guide for the seven roles of women framework (Church, n.d.)[5] with the help of several Yoruba mothers; and (c) pretesting the questions developed in the first two processes in a village outside of the IRDP. 26 women co-operative members were interviewed in one of the IRDP villages (Aganran).

iii. The study revealed that these women did not adopt the family planning technology. This was due to (a) the women's view of motherhood -- for security at old age and in the husband's home, and status both in the society and in the husband's family; and (b) men's negative attitude towards family planning.

iv. This study however revealed that some of the ingredients for fertility decline, according to Kocher[6] were missing.

(a) That there was no evidence that the women's incomes were increasing;

(b) It was not certain that the survival rate was high enough to let mothers plan with assurance;

(c) There were no family planning facilities in the village;

(d) The desire for smaller families could not be ascertained.

Project 3: Use of loans

i. The purpose of this project was to find out the details of how women in one of the project villages who were members of the multi-purpose co-operative went about their trade and factors which made one woman more successful than another. Importantly, the study was designed to observe what the women would do with credit if extended to them.

ii. A 30% interest rate loan of ₦2,000.00 given to the co-operative by the University of Ife IRDP was, shared equally among 24 credit worthy members of the society after setting aside ₦560.00 for deposit in the society's bank account. So, each woman received a loan of ₦60.00.

iii. Each loan recipient was interviewed once a month to collect data on their trading activities. All but four of the loan recipients said they normally had more than ₦60.00 in trading capital. Study data showed that two-thirds of the women invested less than ₦60.00 on their average transactions. For five of the women, their invesment was slightly more than this amount. Three of the members were operating with more than twice the amount of the loan. The total interest on each ₦60.00 was ₦18.00 payable twice.

iv. For all but five of the women, the profit made during the year were more than cover the cost of the loan. They all paid what they owed but from their gross revenues not from their profits. Only four made a high enough rate of return to cover the 30% interest rate. There was a positive relationship between investment and internal rate of return.

v. Overall, the project revealed that the co-operaive society could act as a rural bank, and that individuals would gain more financially and respond more positively to taking and using of loans if savings policy of the society regarding when individuals could withdraw is liberalized.

Project 4: Adoption of improved maize crib

i. The objective of this project was to determine whether the women co-operative group was capable of adopting technological change of importance to agricultural development.

ii. In order to do this, project staff encouraged the women to build a modern maize crib designed by the International Institute of Tropical Agriculture (IITA). This technology was chosen as one within the women's means, one which would answer a community need, and one which was in line with the women's main concern -- individual trade. As staff assisted in the construction and use of the crib, they kept notes on the activities and effects taking place.

iii. Although the unfavourable weather conditions interfered with the experiment, the rate of use of the crib during the dry season demonstrated that under normal weather conditions, the effectiveness of the crib for storing maize has been demonstrated.

Project 5: Use of modern medical care

i. The purpose of this study was to find out how village women in IRDP took care of their common health programmes.

ii. This was done through three surveys and in-depth interviews with women needing treatment. The objective was to guide project staff on the type of health programme that should be developed to meet the people's need. These surveys were conducted in 1969, 1975 and 1977 with information obtained from 90, 68 and 75 women respectively.

iii. The study showed that the respondents did not use the modern or Western sources of medicare except in child delivery. They relied most on traditional healers, self-medication with drugs purchased from chemist/patient medicine stores and medication from untrained drug peddlars.

iv. Reasons for these findings include costs and various difficulties (transportation costs, difficulties faced in the hospital due to respondents' ignorance of hospital procedures, inability to read instructions and receipts, and the unfriendly attitudes of hospital staff).

Project 6: Acceptability of recipes for vended pre-school foods

i. This study examined the factors which must influence the use of local recipe for early childhood feeding using local food vendors.

ii. Two villages in the IRDP in which nutrition education had earlier taken place were chosen for this study. Five women, a 'moinmoin' (boiled bean paste), two 'eko' (Maize ball) and two rice sellers were chosen. Four modified (enriched) local dishes were introduced - soft pepper - free (moinmoin) to which ground fish or crayfish was added; pepper - free rice sauce made of groundnuts and cray fish; mashed beans plus fish and cold paip ('eko') to which palm oil and ground dried fish had been added.

iii. At the vendors level, acceptability was influenced by (a) stability of supply and price of local materials, (b) the keeping quality (shelf-life) of the food, and (c) level of profitability. At the parent's level, the price of the dishes was the determining factor.

Project 7: Potentials for improved pre-school feeding through local vendors

This study was a follow-up to Project 6 discussed above.

i. There were five objectives of the study, namely:

(a) To discover whether a change agent who is not known to the community and who has no professional training and very little education can teach food vendors to prepare enriched foods;

(b) To test the importance of nutrition education in introduction of improved feeding through vendors.

(c) To observe whether meals designed to meet the protein and energy requirements of a particular group of people would actually do so in a free market situation.

(d) To determine whether level of profit would be related to the adoption of enriched food prepared by vendors.

(e) Assuming that profit would be an important factor influencing adoption, the study set out to identify situational factors related to profit.

ii. (a) Six villages in the IRDP were selected for this study.

(b) Foods pepared were animal protein, enriched, softened, pepper-free modifications of common dishes with the participating vendors.

(c) Standard average protein and energy requirements of pre-school were used. Quality of vended intake was estimated by weighing the ingredients used and looking up the protein and amino acid and energy values in FAO tables.

(d) The field workers stayed about 20 days in each vendor's kitchen and sales.

iii. Findings: (a) The primary school level worker was effective in teaching vendors, preparing food and selling them. Her only difficulty was in keeping records.

(b) Adoption was influenced by nutrition education and profit to be made.

(c) Amount of profit made was found to be directly related to average daily sales which in turn was related to number of customers.

(d) Adoption of vending enriched foods was recorded with only one vendor. It was felt that the extra work involved in preparing such foods would not be worth-while.

Project 8: Appropriate technology for Women: the case of maize sheller

i. Women in the villages had traditionally marketed food crops including maize, local white.

ii. The introduction of improved yellow maize introduced change of roles in which men co-operative took over marketing of maize.

iii. To encourage women economic independence and modernize processing, the maize sheller bought and operated by women cooperative was introduced.

iv. The technology was discontinued after two seasons.

v. The factors responsible for the discontinuance include:

(a) Unexpected deterioration of the roads linking the village in which the sheller was located to other villages which were expected to feed it with maize.

(b) Change in farmers' approach to marketing brought about by the introduction of a new variety of maize which was acceptable for local consumption and the simultaneous introduction of storage cribs. These meant that marketing would be phased and that the shelling crisis no longer existed.

(c) Another factor accounting for discontinuance was inherent in the perception of the technology itself. Because it is more efficient to operate by pedal rather than by crank (hand), it was seen as being more appropriate for men than for women.

(d) Other factors include:

(i) inability of the women to manage the machine efficiently.

(ii) the machine demanded a reversal of the mutual obligations system concerning maize shelling.

Whereas women had previously been obliged to shell maize for their husbands, husbands were now being called upon to patronize their wive's machine. This call for more study of (i) better understanding of innovation-decision process at both the group and individual levels; and (ii) attitudes of men towards the ownership of technology by women.

CONCLUSIONS

The findings of the studies reviewed in this paper demonstrate very clearly that rural women within the IRDP area were rational economic beings whose behaviors in technology adoption were guided by factors of costs and returns.

i. The women desired to determine and regulate their actions rather than being subjects of stereotyped government regulations;

ii. With provision of ingredients for family planning and support from their reference group (the men), they will adopt family planning;

iii. They were capable of making judicious use of loans;

iv. With improved management skill and elimination of issues of role conflict, they will do well in agricultural technologies;

v. Profitability, costs and availablity of materials were major determinants of adoption of improved nutrition practices.

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"Science Abled: Opportunities in Science for Women with Disabilities

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The Need

In 1983 the number of women in non-traditional science fields in the U.S.A. was increasing, but women with disabilities were still less likely to opt for science training or careers. In fact the number of disabled women in any occupation - traditional or non-traditional - was and remains dramatically low. Just 20% of women with disabilities work, compared to 59% of non-disabled women in the same age range (Bowe). When women with disabilities are working, they can expect to earn about 56% as much as men with disabilities (Atkins).

Although accurate data are not available, it is also clear that the number of disabled men entering science and technology is small. It was for this reason and because they share the same viewing audience, that we decided to design the project for both women and men with disablilites. As Betty Vetter, Director of the Commission on Professionals in Science and Technology, said in a personal interview, "With fewer eligible people for training at the college level (in the U.S.), the need to utilize the best minds in science and technology is obvious. We won't have the best unless we utilize *all* of the available talent pool."

Beyond the labor demands in the fields of science and technology, there are several other reasons why directing disabled individuals into fields of science and technology makes good sense. Good education leads to employment and contributes to the well being of the individual as well as the society. According to Harris, "about four times as many working disabled persons have a four-year college education as those who don't work." Compared with those who do not, those who do work are "...more satisfied with life, much less likely to say that their disability has prevented them from reaching their full potentials as a person ..." (The ICD Survey of Disabled Americans) In addition, the job performances of disabled workers is very good. A survey of 921 American companies showed that "88% of the top managers, 91% of the equal employment officers at the companies and 91% of the department heads rated the performance of disabled workers as good to excellent... At the same time, 66% of the managers polled said that a lack of qualified applicants was the main reason they had not hired a disabled person in recent years." (Hevesi)

The Barriers

The barriers which discourage young non-disabled women from entering science or technology exert the same if not greater influence on young women with disabilities. There is a critical shortage of role models. There is a lack of educational and hands-on science opportunities. There is heavy counseling pressure on disabled persons to enter service- oriented careers, especially serving the disabled population. There are significant attitudinal barriers about whether people with disabilities should be employed at all.

In general, why do physical disabilities and low employment status seem to be related? There are four general areas to consider in looking for an answer:

1. Early influences can discourage disabled individuals from accepting goals that require successful and competitive training. (Weinberg)
2. The lack of helpful feedback from teachers and counselors. (Chandler)
3. The lack of appropriate classroom planning and activities. (Damborg)
4. The expectations encountered from the general life environment. (Pati and Adkins)

Conspicuously missing from the list of causes for the relatively poor showing of persons with disabilities in employment achievement is an intrinsic ability to perform.

The Goals and Design

In 1985 a project entitled Science Abled was funded by the Women's Educational Equity Act Program in the U.S. Dept. of Education for the purpose of encouraging young women and men with disabilities to prepare for and enter into careers in science and technology. The Science Abled project uses a role model approach to answer several of the concerns which students with disabilities and those who are responsible for their education and employment may have about opportunities in science and technology. These concerns include academic preparation, ability to perform, necessary accommodations in the classroom and on the job, communication, stamina and safety, and attitudinal barriers dealing with discouragement.

Two videotapes which feature interviews with role models with physical or sensory disabilities were produced, one for students and the other for employers. The student videotape, Science Abled: Good Minds at Work, consists of two parts, each twenty minutes in length: "Work and Accommodations" and "Preparing for a career in Science or Technology". The second videotape which addresses the concerns of employers is entitled Science Abled: Return on Equity, and is thirty minutes long. Both videotapes have secondary audiences of educators and parents. Much on-the-job footage is included showing the role models at work and utilizing various accommodations.

Seven role models appeared in the videotapes - four women and three men - including a medical technologist, systems analyst, chemistry professor/researcher, physician, biology teacher, computer programmer and physicist. In addition appearances were made by several students, supervisors, co-workers and employers. Resource manuals accompanying the videotapes include a user's guide and sources of information about science careers, science organizations and disability issues.

The Results

Currently the final versions of the videotapes are being edited. Preliminary versions were shown to 285 viewers which included students, educators, parents, scientists and media experts. Evaluations of the tapes were derived from follow-up discussions, and from questionnaires about the effectiveness of the videotapes which the viewers completed.

Of most interest to a GASAT audience, is the reaction of students to the videotape, Science Abled: Good Minds at Work. Of the 56 students with disabilities who reviewed the preliminary version 91% agreed that the tape showed them that "women can succeed in science"; 86% agreed that the tape showed them that "it is important to take math and science in high school"; and 68% agreed that the tape showed them that "science offers good opportunities for people who are disabled."

The videotape was also shown to 156 non-disabled high school students in college preparatory biology and psychology classes. The results included: 93% agreed that the tape showed them that "women can succeed in science"; 77% agreed that the tape showed them that "science offered good opportunities for people who were disabled"; 77% agreed that the tape showed them that "it is necessary to take math and science in high school."

The biggest discrepancy between the groups was to the question of whether the tape showed them that "employers who hire disabled people are fortunate"; 69% of the disabled students agreed, compared to 52% of the non-disabled students. One additional question was asked of the non-disabled students: Did the tape show that "disabled people have a better chance for a job in science than I thought before"? The response was encouraging, 78% of the non-disabled students agreed. This finding suggests that the tape may be of value in dispelling stereotypical attitudes about the abilities of disabled people.

Summary

Although the numbers are still discouraging low, in the past decade more women in the U.S. have enrolled in science-related courses or entered science-related careers. The reasons may be changes in attitudes, expectations, opportunities. But women with disabilities have been consistently less likely than other women to opt for science training or careers. Their reasons are less likely to change unless some concerted attention is focused on expectations and attitudes about them. The Science Abled project is designed as one tool in the effort to increase the number of students - females and males - with disabilities who choose science or technology as a course of study or career.

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ENCOURAGING GIRLS AND WOMEN IN SCIENCE : GETTING GOING IN WELLINGTON, NEW ZEALAND

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INTRODUCTION

The low participation of girls and women in education and employment in science in many countries is well known and intervention programmes have been instigated. In New Zealand recognition of the low employment of women in science and technology has prompted several intervention programmes since the late 1970s (Bradford et al, 1985). These programmes have been sponsored by employment-related organisations and have provided information and training for women in non-traditional careers.[1] The low proportions of girls and women enrolled in science and technical subjects at school and in tertiary institutions in New Zealand is less generally recognised than the low proportions in employment and intervention other than in some individual schools had not been undertaken in 1984 when the initiative discussed in this paper began. This paper will describe the process by which a resource group for teachers and a support network for women working, or wanting to work in the sciences were established in Wellington, New Zealand, and will identify factors influencing the success of the initiative.

NEW ZEALAND RESEARCH PRIOR TO THIS INITIATIVE

Bunce (1970) reported gender differences in subject choice at secondary school. Girls more often chose languages, social science and biology, while boys more often chose mathematics and physical science. Romanovsky (1975) found a similar pattern of subject choice at university. The IEA (International Association for the Evaluation of Educational Achievement) survey of science, carried out in the early 1970s, showed higher achievement of 14-year-old boys in science in New Zealand than of 14-year-old girls (Kelly, 1978). Sex-role stereotyping in school science textbooks was reported to favour males, and this was strongest in the most recent junior secondary textbooks (Department of Education, 1980). In the early 1980s large differences in male and female participation in science subjects were still evident (Burns, 1982; Stead, 1982) though differences in mathematics participation had been substantially reduced at the middle secondary level (Stewart, 1981; Burns, 1982). The differences in girls' and boys' participation in mathematics and the physical sciences at senior levels occurred in spite of similar achievement in mathematics (Stewart, 1981) and science (Burns, 1982) the previous year. Girls' participation in chemistry and science at middle and senior levels was slightly higher at single sex schools than at coeducational schools (Norman, 1981).

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[1] The Equal Pay Act was introduced in 1972 and the Human Rights Commission Act in 1977.

Attitudinal differences of girls and boys toward science subjects were also reported in the above studies. Stead (1982) found boys had more positive attitudes than girls toward junior science and a wider set of beliefs about the likely consequences of studying science. Burns (1982) reported more positive attitudes of boys toward the physical sciences and more positive attitudes of girls towards biology. Boys also had more physics-related out-of-class interests than girls, and girls more biology-related interests than boys.

Since the mid-1970s several writers (Macdonald, 1975; Keir, 1979; Bradford, 1980; O'Connor, 1982) have expressed concern about the low participation of women in scientific and technological occupations. Among a sample of 2553 scientists Keir reported lower qualifications of women than men, employment in teaching rather than research, and a greater proportion with a break in service.

THIS INITIATIVE

In 1984 a case for the greater participation of girls in science and technology education and of women in related occupations in New Zealand was made to a workshop of the New Zealand Science Teachers' Conference (Burns, 1984). A positive response was received from the members of the workshop who were mostly women; but among the majority attending the Conference informal discussion indicated that there was little recognition that a problem existed.

The author set up a committee, in late 1984, to investigate ways in which public

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awareness of girls' and women's low participation in science could be raised, and more girls and women could be encouraged to participate in science. Women representing a range of science and social science disciplines, professional organisations and areas of employment (including teaching, research and administration), who had expressed interest in the issue or become actively involved, were invited to join the committee. At the outset the committee comprised ten women though this number later grew to sixteen. Most of the women occupied senior positions in their employment. The committee called itself the Council for the Advancement of Women in Science and Engineering (CAWSE). It set priorities for action.

In June 1985, CAWSE organised, in collaboration with the New Zealand Association of Scientists, a week-day symposium on Women and Employment in Science and Technology. The aim was to raise public consciousness that a problem of girls' participation in science and technical subjects at school and of women's employment in science and technology in fact existed, and to seek direction for further action. The symposium was advertised in Government departments and large companies with scientific or technological interests, professional organisations and schools and tertiary institutions in the Wellington area. It was opened by the recently appointed, first Minister of Women's Affairs, speakers included a well-known educationist and broadcaster, and the venue and lunch were provided by a large multinational company. One hundred people attended, the maximum that the venue could accommodate. Participants came from all over the North Island including one representative of the new Auckland EQUALS: Maths/Science Network (Morton and Reilly, 1987). Although the symposium was directed toward both men and women, only 10% of participants were men. Large companies and Government departments generally saw the low participation of women in science and technology as a women's problem. Analysis of the outcomes of the symposium workshops indicated the need for two groups, a resource group for teachers and a support network for women working in, or wanting to work in the sciences. In early 1986 Women Into Science Education (WISE) and the Association of Women in the Sciences each met for the first time and by mid-year formal election of officers had taken place. The groups

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took over all of the activities of CAWSE, and CAWSE was disbanded.

WOMEN INTO SCIENCE EDUCATION (WISE)

Aim - *To promote the education and interest of girls and women in the sciences, so that they may develop their potential to understand the world, participate in the concerns of the community, and be employed in scientific and technological fields.*

Objectives

- *To promote affirmative action for the education of girls and women in the sciences.*
- *To promote a non-sexist science education.*
- *To provide a forum for the exchange of ideas on non-sexism in education in the sciences.*
- *To liaise with teachers from different areas of education, and with education researchers and administrators.*
- *To liaise with related groups, for example, science teachers, vocational guidance workers and women scientists, through the new Association of Women in the Sciences.*
- *To establish a network of people interested in this issue.*

WISE is open to women and men. It has held seven meetings in its first year. Speakers have included the conveners of the first and present GASAT conferences, Dr Jan Harding and Dr Jane Butler Kahle, education researchers and people involved in positive action programmes for employment of women. A newsletter, which includes background information and suggestions for classroom activities, has been published prior to each meeting. WISE has prepared a list of women scientists (in collaboration with the Association of Women in the Sciences) willing to speak in schools, and has set up a "hands-on" day for female secondary school students at the Central Institute of Technology. Members have been involved in organising two in-service courses for teachers, in writing resource material for schools and articles for the newspaper, in interviewing for radio, and in consciousness-raising of the staff of their own schools. There are now over forty financial members though the newsletter is mailed to a further fifty institutions. The possibility of establishing similar groups in two other areas is currently being investigated.

ASSOCIATION OF WOMEN IN THE SCIENCES

Aim - *To encourage women to use and develop their scientific abilities and to achieve their full potential.*

Objectives

- *To provide social interaction with others with similar interests who believe that science is an important female activity.*
- *To provide a scientists' network for women to share scientific information, experience and skills.*
- *To provide an exchange forum on employment and career possibilities.*
- *To assist women to gain confidence as scientists and increase self-knowledge and understanding.*
- *To provide visibility of scientists who happen to be women, and to act as role models.*
- *Eventually to form a national group to speak on issues relating to women and science.*

The Association is open only to women and has met monthly. Meetings have been informal and the opportunity for social interaction has been provided. A speaker was invited to some meetings. The problems for women working in a male-dominated area and in a largely male environment have been addressed. A sequence of three meetings on public speaking and the presentation of scientific papers, and a one-day seminar on the setting and realisation of personal and career goals have been held. There are now almost forty financial members. One member has organised two seminars for women along the lines of the 1985 symposium, in her own large Government department.

FACTORS INFLUENCING THE SUCCESS OF THIS INITIATIVE

Although it is difficult to measure the success of an initiative such as the one described above, an indication is given by the nature of the activities undertaken and the response received. The large attendance at the Symposium and the wide media coverage suggest that an increase in public awareness was achieved. The establishment of the teachers' group and network for women in the sciences indicates that a need is being met. The activities of these groups are now involving a wider range of people. Some factors influencing the development of this initiative are given below.

1. Personnel

Members of the planning committee (CAWSE) were concerned about the cultural and employment consequences for women receiving little education in the sciences. The members reflected a diversity of interests and expertise, had considerable standing in the science and education communities and a wide range of experience and contacts.

2. Liaison with other groups

Liaison was established with Government departments, including the Department of Education, Department of Scientific and Industrial Research and the Department of Labour, with established women's groups and with professional bodies. Contact was facilitated where women's officers had been appointed.

3. High profile support

Visible support by the Minister of Women's Affairs, national and internationally recognized speakers, and a large multinational company gave status to the programme. Support by the Department of Education gave official sanction and practical assistance.

4. The women's movement

Considerable groundwork had been done by a number of women's groups of more general interest established in New Zealand since the mid-1960s. With the election of a new Government in late 1984 a Minister of Women's Affairs was appointed, and a Ministry was established by 1986. As a consequence Government departments, private industry and professional organisations may have been more supportive than might otherwise have been the case.

5. Science education and curriculum development

In 1978 the first New Zealand Science Teachers' Conference was held, and the following year the Learning in Science Project (LISP), a Government-sponsored research programme got underway. Dissemination of the results of this research had encouraged growth and development in science education throughout the country. In 1985 community involvement was sought in a review of the school curriculum which made it apparent that there was the real possibility of change and of influencing that change.

6. Overseas research and intervention programmes

Research carried out overseas, and the consequent intervention programmes such as Girls into Science and Technology (GIST) and Women in Science and Engineering

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(WISE) in Britain, Increasing the Participation of Girls in Mathematics and the Women in Science Enquiry Network (WISENET) in Australia, and the Association of Women in Science in the United States provided encouragement and direction for the development of programmes in Wellington.

Steps towards non-sexist education in New Zealand have been taken by the appointment of three women's officers in the Department of Education in 1986, and proposals for further steps have been made in a draft report of the Committee to Review the Curriculum in Schools (Department of Education, 1986). Programmes to improve girls' education in science and technology may well receive particular impetus in the future as a consequence of the growing concern about science education (Vere-Jones, 1987) and the supply of people with the required skills for employment in science and technology (Beattie, 1986) in this country.

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Acknowledgement

Thanks are extended to Dr Janet Bradford for constructive criticism of the manuscript.

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WISE WOMEN AT THE OPEN UNIVERSITY

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Summary

Since 1984, the Technology Faculty at the Open University in the United Kingdom has had a Women Into Science and Engineering working group which aims to increase the participation of women students in its courses. The activities of the group are described and evaluated. The role and effectiveness of such a small special interest pressure group in a large educational institution are also addressed.

Introduction

The question at issue here is whether or not an open university can make courses which traditionally have low appeal to women students genuinely open to them. The Open University(OU) Women Into Science and Engineering(WISE) working group has taken up the question within the Technology Faculty and developed it over the last three years. It has had some success and suffers some frustrations.

This paper begins by outlining the institutional context in which the group was formed and now works. It then describes its efforts to improve student recruitment and support in Technology Faculty courses and to liaise with other faculties and projects. Finally, some reflections are offered on the role of WISE as a pressure group within both the faculty and the university as a whole.

The Open University

The British OU, which has an international reputation for its expertise in distance teaching, is now in its seventeenth year. It is a national university, providing adults throughout the United Kingdom (UK) with the opportunity to study part-time for a degree. Admission is on a first come, first served basis for about 20 000 undergraduates each year, while at least twice that number of applications are received. There are no minimum entry qualifications; indeed, about 35% of new undergraduates do not have the minimum requirements for entry to a traditional British university. In 1985 there were 67 000 undergraduates studying specially prepared multi-media courses across six faculties: Arts, Education, Mathematics, Science, Social Sciences and Technology. A similar number of students were studying more than 200 non-degree courses or packs.

The Faculty of Technology

The Technology Faculty at the OU comprises five departments or disciplines: Design, Electronics, Engineering Mechanics, Materials Science and Systems. It offers both subject based and interdisciplinary courses covering the spectrum from 'soft' technology (Systems Behaviour, Design Processes and Products) to 'hard' engineering science)Thermofluid Mechanics and Energy, Control Engineering).

Students interested in pursuing a degree in any aspect of Technology begin by studying the one-year foundation course, T101 Living With Technology (approximately 15 hours study per week for 36 weeks). This is an introduction to technological decision making, dealing with issues concerning shelter, communications, energy usage, natural resources, food and health. It is the belief of the faculty that future engineers and technologists should begin their studies with perspectives on the role of the engineer in society. They can then continue their degree by taking more specialised technical courses according to their specific interests.

WISE in the OU Technology Faculty

Early in 1984, spurred by the impetus of the national WISE year campaign, a WISE working group was formed within the OU Technology Faculty to investigate the problems of very low numbers of women students on Technology courses. The statistics with which the group was faced form part of Table 1. Only Food Production Systems, with its connotations of Biology and Home Economics, both traditionally womens subjects, had anywhere near equal numbers of women and men students.

The open principle of the OU, while operating reasonably well at an institutional level, where the overall proportion of women undergraduates was stable at 42.5%, had not been sufficient to encourage women to make non-traditional choices. The typical Technology student was a man between 25 and 35 years old, already employed in a technical environment, possibly sponsored by his employer and using his OU studies to improve his career prospects.

Publicity

After some discussion, the WISE group decided to take as its baseline the aim of improving the number of women on the foundation course, T101. It supported the faculty's view that the course is very appropriate for women coming fresh to the area and anticipated that, having studied it, they would feel both more confident and better prepared to tackle higher level courses.

There followed a publicity campaign. A special leaflet was designed to recruit to T101 both women new to the OU and those already in the system who are required to study a second foundation course. It emphasised the way in which the course deals with the impact of technology on everyday life and its assumption that students will not have undertaken any previous mathematical or technical study. As well as illustrating the structure of the course, it listed the titles of higher level courses and made the point that, in a crisis of high unemployment, 'those few jobs that are available in the UK are in fast developing new technologies.' A technology profile OU degree might open career doors that could not be unlocked by degrees in other faculties in the current political and economic climate.

Most OU technology courses have an obligatory one week residential summer school component; those are located on the campuses of other universities. Meetings for women were held at technology summer school sites, sometimes for women technology students only, sometimes for students at other parallel summer schools on the campus too, to discuss and explain the wide range of courses offered by the faculty. A video was made by the WISE group for this purpose and shown at the meetings. It describes how studying T101 had eventually led to successful careers for two women with different interests.

Table 1 Women Students Registered for Technology Courses : 1983 and 1986

(Courses are ranked according to % women undergraduates in 1983.)

Course Code	Title	1983 No of Women	1983 Total	1983 %Women	1986 %Women
T273	Food Production Systems	195	423	46	not available
TM361	Graphs Networks and Design	132	574	23	35
T101	Living With Technology	807	4355	19	24
T241	Systems Behaviour	82	450	18	18
PT281	Industrial Relations	47	258	18	not available
TD342/T301	Systems Performance	20	122	16	15
T243/T244	Systems Organisation	54	350	15	21
T263	Design Processes and Products	95	687	14	15
T361/T362	Control of Technology	19	159	12	13
TM222	The Digital Computer	176	1483	12	13
TM281	Modelling by Mathematics	104	925	11	10
T401	Technology Project	5	49	10	7
T252	Engineering Materials	12	298	4	4
T353	Failure of Stressed Materials	4	92	4	1
T283	Introductory Electronics	40	1174	3	5
T352	Materials Processing	4	118	3	8
T232	Engineering Mechanics : Solids	8	329	2	1
T291/T292	Instrumentation	19	933	2	3
T233	Thermofluid Mechanics and Energy	4	327	1	3
T321	Telecommunications	2	391	1	2
T391/T394	Control Engineering	2	308	1	1
T234	Environmental Control and Public Health		not available in 1983		34
T281	Basic Physical Science for Technology				10
T326	Electronic Signals Processing				3
T392	Engineering Product Design				3
T331	Engineering Mechanics: Solids and Fluids				2
T393	Electronic Materials and Devices				2

Note: The second digit of the course code indicates the level of the course: 1 denotes foundation level, 2 denotes second year level and 3 or 4 denotes third or fourth year honours level.

Source: OU Survey Research Department.

While it is very difficult to assess the impact of these publicity initiatives in an environment where many factors operate, there is no doubt that they have contributed to the slow but steady rise in women students taking T101. Table 1 also shows that there have been small improvements in the participation of women students in higher level courses, although they are only of the order of one or two percentage points. However, outside the OU schemes for retraining mature women in technology have recruited well too. This suggests that a number of initiatives, of which the WISE group is only one, are beginning to have a cumulative effect in changing attitudes to the opportunities for women in non-traditional fields.

Student support

OU courses are taught in local study centres throughout the UK by part-time staff appointed and specially trained to handle the multi media course material; often they are full-time faculty members in other universities or colleges. At the suggestion of the WISE group it is now Technology Faculty policy to appoint women tutors wherever posible, so that students are encouraged by the example of a positive role model. Unfortunately the pool of suitably qualified women applicants is very small, despite letters from the WISE group to appropriate newspapers, journals and professional institutions soliciting applications. Even with regular reminders to the Technology Staff Tutor Group, the body responsible for tutor appointments, in 1987 less than 10% of technology tutors are women.

The WISE group has also prepared an audio cassette which forms part of a resource pack for tutors on T101. A taped discussion between some experienced women staff alerts new and existing tutors to the particular problems women face in the predominantly male milieu of a technology tutorial group meeting. Some aspects of the 'chilly climate in the classroom' (Hall and Sandler 1982) are thereby alleviated.

At the summer school meetings some women students expressed doubts about their own suitability for technological careers and their own personal ability to cope with both their family circumstances and a career at the same time. The WISE group identified a need for a careers booklet which expanded the theme of the videotape and could be used in a counselling context with women students to reinforce their tentative first steps towards a technology degree profile. From 1987 the CAREERWISE booklet will be available (Kirkup 1987). Written by a member of the WISE group, it is a series of nine case studies of OU women students who have managed to find satisfying jobs in a technical environment. As well as concentrating on their successes it outlines the difficulties the women have had to face on the way and includes details of how they juggle their domestic commitments to dovetail with their demanding professional lives.

Liaison

The WISE group has been anxious to avoid accusations of being internally divisive within the OU by being seen to 'poach' students from the other faculties with an under-representation of women. It has always invited members of the Science and Mathematics faculties to its meetings and welcomed proposals for joint initiatives. However, these have taken some time to emerge because the basic research on the position of women students in the Technology Faculty had been done before the formation of the WISE group (Swarbrick 1980) whereas the situation of women in Science and Mathematics has yet to be documented.

In fact, Ailsa Swarbrick's research had quickly led to the establishment of a Women In Technology (WIT) bursary scheme which provides financial support and special counselling. It now enables 96 women annually to study Technology courses and attend a free preparatory weekend before the start of the academic year. This project, which stemmed from the

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enthusiasm of a regional member of staff, had flourished largely outside the Faculty and represents a remarkable woman-oriented or feminist model of learner support (Swarbrick 1986). The WISE group has been able to support the most recent phase of expansion of the project and, by providing a channel of communication, has tried to bring WIT'S successes and development problems to the regular attention of the Faculty.

Student contact for the WISE group was initially sporadic. However, in 1986, a student who had proposed the formation of a Technology Womens' Information Network to put individual women technology students in touch with each other joined the group. It has been able to help her establish the network and suggested that the students might affiliate to the Womens' Engineering Society. In return, the group has benefitted from her suggestions on other aspects of its work.

Future plans

Activity in the WISE group continues. Currently it is engaged in examining strategies for teaching hard technology to women and is collecting data from inside the OU and from other sources such as the Womens Technology Traning Centres around the UK. These specialise in teaching non-traditional skills, usually electronics and computing.

It is also hoping to organise meeting for women tutors in Science, Mathematics and Technology to enable them to discuss their own particular isolation in the OU system, to share their coping strategies and to establish solidarity with each other. Where this might lead is still a matter of conjecture, but such contacts have exciting possibilities.

The role of WISE as a pressure group

WISE is an informal working group of Faculty staff who are concerned about women in technology issues. About a dozen people attend the bi-monthly meetings, including two men; one is the Dean who has been consistently supportive. The mailing list is long, but as membership of the group is voluntary and taken on in addition to other work commitments, activity is maintained by a small corps of dedicated women who see the issues as central to the Faculty and to the OU.

The immediate environment of the group, the Technology Faculty, is mainly composed of men, apart from secretarial staff who are, of course, all women. WISE reports to the policy making body, the Faculty Board: of the 205 voting members in the year 1986-87, only 30 (14.6%) are women. It is notable that until 1986 there were no senior women on the academic staff; there is now one woman of Senior Lecturer status. While the group reports regularly on issues of significance to women at Faculty Board and has always received endorsement for its activities, the climate tends to be one in which approval is readily given for schemes which do not impinge too closely on the work of other members of staff. There is goodwill from colleagues, but little active support.

Recent financial constraints imposed on the university have in turn imposed pressures on staff, creating an atmosphere which does not leave time for individuals to become involved in projects outside the mainstream of course production. Thus, one way in which the WISE group can impact on the collective consciousness of the Faculty is to provide an input to course teams; hence its interest in teaching strategy. Course preparation has high status at the OU: contributions are always taken seriously. At the most basic level the WISE group can point out that examples in course material should avoid the assumption of a male culture in which everyone is familiar with the moves on a football field or the parts of a car engine. Since T101 is undergoing a rewrite at present, the WISE group has had the opportunity to discuss with the course team the possible effect on women students of introducing a substantial practical computing element into the course and, concomitantly, requiring students to purchase a personal computer for home use.

Prospects

The OU houses a number of womens iniatives, but links between them are tenuous, depending solely on the personal contacts of their participants. There is no university wide forum for the development of womens issues, no Equal Opportunities Officer or Pro-Vice Chancellor with special responsibility for women. So far the OU has not even declared itself an equal opportunities employer. This lack of commitment to women at an institutional level is reflected in the attitudes of colleagues to the womens initiatives and endorses their peripheral position in relation to the 'real' work of the university. It contrasts markedly with the ideology of openness to which most staff strongly subscribe and with the very effective measures of positive discrimination which have been taken to ensure that disabled students participate equally in the OU.

A strengthening of the university's commitment to women would immediately have the effect of moving the WISE group and its activities nearer to the central concerns of the Technology Faculty. It might then be possible, for example, to hold workshops for male colleagues to discuss the position of women in technology both inside and outside the OU and to undertake other regular consciousness raising activities.

A group whose existence was institutionally recognised would command more authority to be heard. It would also be in a more powerful position to request the release of staffing and financial resources to support its work. Having the capacity to develop research links with simillar groups in other universities might allow WISE to attract external funding; the university's reputation would be enhanced and its initial commitment would have paid off.

Meanwhile, the group continues making progress slowly. It looks forward to a time when 50% of technology students are women and to a substantial increase in women on the part-time and full-time staff of the Faculty.

Acknowledgements

I wish to thank friends and colleagues, in particular Gill Kirkup and Ailsa Swarbrick, for their help in developing this paper.

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ROME WAS NOT BUILT IN A DAY

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SUMMARY

Since 1979 a number of activities have been arranged at Linköping Institute of Technology (LiTH) to increase girls' interest in technology. In Sweden, as in other countries, girls take little interest in technology and are not inclined to choose a career in this area. During the past few years, a project for stimulating girls' technical interests has been developed and carried out on a somewhat larger scale than before.

The project was described briefly in a paper by Ingrid Granstam, written for the GASAT 3 conference in London (see documentation for GASAT 3, pp 40-47). The following paper will concentrate on a few of the activities in the project:

- Mini-courses for girls

Mini-courses for girls in upper secondary school have been arranged each year at the Institute since 1979. The background and objective of such courses is the fact that girls know very little about higher technical education and do not even consider it as an alternative when choosing a career. During the past few years, mini-courses have also been arranged for girls in lower grades, as we know that the first choice towards the future career is made when the pupil selects an upper secondary school course program.

- Visits to schools by women technologists

For each of the past few years, some 30 women students at the Institute have been involved in activities directed towards girls in the compulsory school and the upper secondary school and towards teachers from the intermediate to the upper level of the compulsory school. The women technologists have not only informed the girls about experiences of studying at an institute of technology but also served as instructors, helping the girls carry out experiments in small groups.

- Special projects

The philosophy of our project is that it is necessary to work not just at one or two levels, but at as many as possible, starting with nursery school. Some of that work will also be described here.

The technology students have participated in different school projects, in some cases involving a whole school administration area. Technology has been introduced at the department of nursery school teacher training at Linköping University and a special room for hands-on experience has been built up there.

At present, a special project group of six persons is responsible for the development and administration of school programs, school contacts and maintenance of material. The group includes teachers, administrators and students, who all work on the project part-time.

The project will continue through the academic year of 1989/90. The aim is to increase to at least 30% the percentage of women enrolled at the Institute. Our strategy has been and will continue to be information directed to girls at all school levels. The project is financed by Linköping Institute of Technology.

MINI-COURSES - A WAY TO PRESENT TECHNOLOGY TO GIRLS

Mini-courses are arranged by all the Swedish institutes of technology, but LiTH, (and Luleå University of Technology) has the longest experience of such courses in Sweden.

At LiTH, mini-courses are arranged for girls at different school levels:

Upper secondary school

Most frequently the courses are offered to girls in upper secondary school, who are enrolled in natural science. The background and objective of such courses is that girls know very little about higher technical education and do not even consider it as an alternative when choosing a career. During 1986 we have also offered the course to girls who have chosen technology courses in secondary school, having found that they too need such information. They are evidently no more inclined to go on to higher technical education than the girls taking pure natural science.

In 1987 a special mini-course will be arranged on an experimental basis, for a group of unemployed women, who follow a specially designed course program administered by the local adult education authority in order to receive grades in math, physics, chemistry and technology corresponding to the engineering course program at upper secondary school level. Most of these women finished upper secondary school, but none studied natural sciences.

The mini-course is intended to present the engineering profession in such a way that it becomes a realistic alternative. The participants in the course are, moreover, expected to tell their classmates and other people about the course and their experiences from it. In that way they can contribute to the dissemination of information about higher technical education.

The course is organized as follows:
During two or three days (depending on their educational background) some 60 girls within a geographical area of approximately 300 kilometers from Linköping visit the institute. They are in their next to the last year at school. They meet women technologists and receive a great deal of information about technical studies. The purpose is to give as comprehensive and realistic a picture of higher technical education as possible. During the course most of the participants are house guests of the women technologists. The girls are also introduced to experimental work at a number of the institute's departments, where women technologists often serve as instructors.

Another important part of the course is that the girls get an opportunity to meet women graduate engineers who work in industry. These engineers are selected with great care so that they represent different areas of industry and different age groups and have as varied a personal background as possible. They talk about both professional and personal aspects of being a woman in a male-dominated profession. The various womens' associations that have been formed at the institute during recent years take an active part in the realization of the course, especially this latter part.

In 1983, four weeks of on-the-job practice in industry was offered as a complement to the mini-course, an arrangement that was greatly appreciated by the participants. The various jobs were made available with the help of the Swedish Employers' Association. This kind of on-the-job practice was definitely an asset to the mini-course, but was rather difficult and time--consuming to organize. Therefore we have not taken it up on a regular basis.

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In November 1986, the course was given for the ninth time. Can we say that the courses have produced any effects?

To find out how the participants choose a career after graduating from secondary school, we send out a follow-up questionnaire about two years after they participated in the mini-course, that is, when most of them should have entered some kind of education or job. Five such questionnaires have so far been sent out. One of the questions asked was: "Of what significance has the mini-course been to your choice of career?" The girls were to choose one of five value judgments, ranging from "Very significant" to "Not at all". The majority of the girls answered that it had been very or fairly significant. Many also commented on their choice. There were mainly two types of comments: the course had been significant either because they now considered engineering as a serious career alternative which they did not do before, or because they found out that higher technical studies would not suit them. Around one third of those who have answered the questionnaire (about 20% dropout) had actually taken up engineering or planned to do so.

Has the number of girls enrolled at LiTH increased since the start of the mini-courses? Yes, it has. In 1980, the first year when the participants in the mini-course could apply for higher education, the percentage of women among the students enrolled at LiTH increased remarkably for at least two of the most male-dominated engineering programs. During the seventies, the average percentage of women enrolled in the mechanical engineering program was around 4%, but between 1980 and 1986 it has increased to 17%. (On the other hand, even though the number of women enrolled in the computer science and engineering program did go up in 1980, it has declined during the eighties, being as low as 4% in 1986, which is remarkable when compared to the other programs. We have decided to carry out a study to investigate why girls do

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not choose computer engineering.) Of course, one must take into account, other factors in society that could influence the girls' choice and be careful not to relate changes to one single activity. But the mini-courses have an important role to fulfill - this is confirmed by the evaluation questionnaires all participants fill out immediately after the courses - and they must continue during a considerable period of time. They most certainly contribute to the increase in the number of women enrolled.

Lower secondary school

Arranging mini-courses for girls at lower stages entails many problems. Is it possible to present higher technical education that lies at least five years ahead in a way that can arouse an interest in technology in the girls? The first thing one must do is to bridge the gap between the current school level and higher technical education. Another problem is: which girls can be offered this course? This must be left to the teachers to solve.

We used our experiences from the courses for the older age group. The same approach could be used: let the girls try experimental work for themselves, let them meet role models, that is, women technologists who talk about their studies and who also serve as instructors.
We have arranged one- or two-day courses for seventh grade girls in the compulsory school who take up special math. (Pupils in Sweden must choose one of two alternative math courses: general or special.) A two-day course can include the following. Short and understandable information about technical education and professions on different levels and the ways to take part. Visit to the institute's department of biomedical technology, with a chance to do experimental work. Visit to the technical division of Linköping regional hospital. Experimental work tutored by women technologists (physics, electricity, digital electronics).

If we compare the attitudes of these girls with those of the elder girls, what do we find? The younger girls' attitude is just as positive as that of the elder girls. They all think the courses should continue to be arranged. The younger girls appreciate that they have been able to do experimental work for themselves, that they have been able to talk to students and - perhaps the most important thing: many of them say that they have learned more about technology. Some comments: "I got a new attitude towards technology". "Technology isn't just building cars, like I thought before."

VISITS TO SCHOOLS BY WOMEN TECHNOLOGISTS

It is important that women technologists tell young people about their education and occupation to provide the girls with role models so that they will look upon women engineers as something quite natural. Sometimes they think women technologists are very clever geniuses to whom mathematics and physics are obvious. Therefore it is good for them to meet young technologists and see that they are just like anybody else.

When visiting schools, the engineering students often take the opportunity to tell the pupils about their studies. Quite frequently they are asked to talk not only to the pupils but also to teachers and parents.

Usually, however, their main tasks during the school visit is to conduct experiments. At present, the following laboratory experiments are offered to schools:

* bridge construction

* basic tools

* electric motor

* physics

* electricity/magnetism

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- * Fischer or Lego technique
- * switching circuit theory

In the following we will describe some of the experiments more in detail.

Bridge construction

Some of the most popular experiments among the pupils are those concerned with bridge construction.

With the help of paper, tape, glue and straw, the pupils are to construct bridges. The pupils are given the same amount of material and smallest dimensions of the bridge are defined. The various bridges are then compared and the pupils have to find out which one will get the smallest deflection from a certain load and study which one can carry the heaviest load. This part of the experiment can be organized as a competition, which is very popular among the pupils.

These experiments suit school pupils at all stages, i e from seven to eighteen years of age. They can easily be adapted to the pupils' age group, the size of the group and the time available.

The work can be done in the following way:
As an introduction to the experiments, the pupils are shown an instructive videotape on solid mechanics with many down-to-earth examples. It gives the pupils some ideas and helps them understand some of the problems that are connected with the construction of bridges. They are also shown some bridge models, and how a suspension bridge easily can be built between two chairs with a board and a rope. Finally, the instructor shows some pictures of well-known bridges before the pupils start out on their own.

When the pupils are told that they are going to see which bridges can carry the heaviest load (the largest number of books) they always react in the same way: "I can't build a bridge of only paper that can carry a book!" They are also greatly amazed when, having constructed the bridge, they realize how solid it is. It is not unusual that a paper bridge can be loaded with fourteen or fifteen books before it collapses.

Before loading the bridge, the pupil who has made it is asked to tell the others how she thought out the construction of the bridge. This is a good opportunity for the pupils to practice speaking before an audience.

In this context it is a good idea to refer to some spectacular accidents that have happened to bridges, due to heavy wind, overload or a ship collision. One such accident is related in the videotape mentioned before. This can give rise to an interesting discussion in the group about how the bridges can be reinforced and how to prevent such accidents.

Physics experiments

Physics include a variety of different experiments: the experiments done in the schools often deal with, for instance, sound, light, heat, movement, water, air. Many experiments of this kind can be found in educational books for children.

The materials which the engineering students use for the experimental work must be cheap and easy to handle, since we want the pupils to be able to do similar experiments at home, without having to spend too much money.

The basic tools

By doing simple experiments the function of the five basic tools can be shown, the lever, the wedge, the pulley, the screw and the wheel.

The pupils are usually given a short introduction to the experimental work from a historical viewpoint - they are shown some slides and they discuss how man invented tools for lifting heavy objects.

Here are some examples of experiments that are frequently done in schools:

- A heavy toy car is lifted from the floor up onto a chair by suspending it from a rubber band. The pupils are to measure how much the rubber band stretches. A smooth board is then leaned against the edge of the chair and the car is pulled along the sloping board up to the chair. The pupils measure again how much the rubber band stretches and the group arrives at a conclusion why the stretches are different.
- To understand the principle of the lever, the pupils might lift the teacher's desk by using a crowbar or a broomhandle. By lifting the teacher's desk with different lengths of levers, the pupils can feel the differences in weight and thus understand the usefulness of the lever. The lever can also be exemplified by a seesaw. Various tools can be examined, for instance screwdrivers, wrenches, bottle openers.
- In another experiment the pupils can try to lift heavy loads by using pulleys. The pulleys can be arranged in different ways in order to lift increasingly heavier loads. Finally the pupils can lift each other. The pupil being lifted sits in a swing. This experiment is always a great success.

The basic tools presented this way suit younger pupils best, i e those up to about 12 years of age. For older students, calculation exercises can be added and it is possible to enter into more detailed discussions.

Irrespective of the pupil's age, the basic tools are always presented one at a time, and the pupils play an active part throughout the lesson. The pupils always like these experiments and are amazed by the fact that they are so easy to understand. The basic tools stimulate interest in technology, and so do the other experiments that we offer to the schools.

Administration of the school visits

To get all these visits to schools to function, a certain amount of administration is needed.

In the beginning of the autumn term we sent out a letter to the heads of all compulsory schools and all upper secondary schools in our districts and in our neighborhood. Altogether slightly more than a hundred schools received our letter where we presented our activities and our purposes with the project. We told them what we were able to do to help the girls to increase their interest in technology and asked them if they were willing to collaborate. We also told them that we had to charge them cost price for the visits. This was our first contact with the schools. We asked them to answer if they wanted us to visit them.

As a result of this letter we got in touch with around fifty schools that wanted our services. By telephone, they told us what kind of services they wanted, e g only information, only experiments or both. We then made up a schedule for our visits.

To carry out this project not only school contacts were needed. We also needed to get in contact with women technologists who were willing to make these school visits. Advertisements were distributed in many different places where the technologists have their daily work. Some 30 technologists expressed willingness to participate in these activities. We arranged a "teaching-day" when all the technologists were introduced to the project. They also received further information about the various experiments and how to conduct them. The technologists, some of whom were men, took part in the "teaching-day" and are now all included in our resources pool. When we scheduled the school visits, we phoned or wrote to the technologists to find volunteers. Usually two technologists, but sometimes several, visit each school, depending on the schedule. These activities continue throughout the school year.

SPECIAL PROJECTS

At the Institute of Technology in Linköping different projects have been carried out, where technology students serve as "teachers" in comprehensive school.

One year, for example, six women technology students studying mechanical engineering helped with instruction in technology in three 2nd grade classes at a primary school. They worked in pairs with half a class and had different themes; a harbor, a town and an amusement park. They got the children to build different technical models appropriate to the theme, using a variety of materials such as cardboard, wood, modeling clay, sticks and construction kits.

On each occasion they also carried out experiments appropriate to the theme. The models were later collected to form an exhibition, which was shown to parents as well as to other teachers and pupils.

The project ended with an excursion when the children visited a harbor, a town and an amusement park to compare their models with the real thing.

The children were very interested and always looked forward to technology class. To begin with, the girls in the class were a bit hesitant about making models, but they soon conquered their misgivings and, on the whole, coped with the tasks at least as well as the boys.

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The most noticeable difference between girls and boys in these contexts would appear to be greater self confidence on the part of the boys.

Another year, twelve engineering students were engaged on a long-term project involving a whole school administration area in the vicinity of Linköping. Their task was to introduce technology to pupils in the 3rd and the 9th grade of the compulsory school.

60 pupils in the 3rd grade and 60 pupils in the 9th grade, were given 3 lessons on 6 occasions during a single term. The students from LiTH served as instructors. In the 9th grade, two male students taught 20 boys and four female students taught 40 girls. In the 3rd grade, three male and three female students taught a mixed group of 60 pupils. The instructors carried out some simple technical experiments together with the youngsters. Instructors, school teachers and pupils alike were very pleased at the end of the term with this method of technical training.

The project showed that

- the girls and boys did the same experiments with equally good results.
- the girls showed as much interest in science as the boys.
- technology introduction was equally successful at both levels.

Should technology be introduced as early as the nursery school?

The Swedish nursery school caters for children up to 7 years of age. Children should be encouraged to take an interest in technology as early as nursery school age. It is particularly important to stimulate girls' interest in technical things. Nursery school teachers must also be aware of how very important they are for the child's choice of occupation. The majority of children exhibit typical sex-role behavior very early. Nursery school teachers can thus seek to change attitudes in the children and also to try to steer them in the direction of a choice of occupation that is not determined on the basis of gender.

It is important to have a well-thought-out plan as early as in the nursery school, to get girls interested in technical matters so that they do not, as is the case with so many women today, risk being so completely at a loss later on in life. Courses and seminars should be arranged for nursery school teachers, which include discussions and demonstrations of working methods and play material on the subject of technology. Simple interest-arousing technical and scientific experiments should be demonstrated and practiced with the aim of providing each course member with ideas for individual activities. It is extremely important that nursery school teachers should find it natural to make their pupils enthusiastic about the subject of technology.

In cooperation with some teachers at the nursery teacher training institute at Linköping University, we have built up a special room for hands-on experience at the institute. This room contains many different materials and tools as well as pedagogical toys and objects such as blocks of varying sizes and shapes, magnetic boards, model seesaws and pendulums.

It is as important a task for nursery school teachers as for primary school teachers to activate the children and arouse [illegible]est in our technical world.

CONCLUDING REMARKS

Many efforts have been made - and are still being made - to get more girls into technology in Sweden. The number of women in higher technical education and the engineering professions is indeed increasing, although slowly. But, as we know, Rome was not built in a day. Many theories and research results suggest several reasons why girls do not enter technological fields. However, everybody in our society is dependent on technology in a great many ways. A positive attitude to the subject combined with a basic knowledge will make it easier for people to function in society and to understand and influence their environment. The object of this paper has been to throw light on problems and possibilities of reaching children at different school levels to arouse interest in technology, as well as to get more girls interested in training for technical occupations.

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ACCESSIBLE, OR MERELY AVAILABLE ? C.D.T. FOR GIRLS

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Increasingly, pupils, staff and governing bodies are becoming aware of the opportunities for learning through Craft, Design and Technology activities. Facilities are now being made available in schools where previously none had existed, yet the full Craft, Design and Technology experience remains inaccessible to a large percentage of pupils, as illustrated by the very small percentage of girls following examination courses.

Research findings have stressed the importance of the physical environment for CDT activities; the nature of the projects being set; the content of available resources; the language being used both during demonstration lessons and the general teacher/pupil interactions. Interaction between pupils also influences perceptions of the subject area. Many pupils, mostly girls, receive the message from the media the CDT is not for them. The poster, for instance, proclaiming 'Woodwork is for you' and showing a large, obviously masculine hand using a plane, or the phrase in an examination syllabus '...may discuss a candidate's work with him if necessary'. If this is further reinforced by unthinking comments or even sexist language, certain pupils will feel unwelcome however interested they may be. In making accessible to girls the learning experience offered through CDT, teachers have to ask questions about the physical environment of CDT activities. My experiences in setting up a new department in a newly amalgamated girls' school were founded on my underlying concern that opportunities for learning and growth offered in CDT should be totally accessible to all pupils. Accessibility is the keyword in the philosophy of the CDT department at Elizabeth Garrett Anderson School.

In the early stages of setting up the department as the newly appointed Head of Department, I saw my role as an observer, defining the needs of the pupils in relation to Craft, Design and Technology. This, I saw as the first stage in establishing the ethos of the department. This included close liaison with the Science and Art Departments as the two departments principally engaged in designing and technological activities. The first year pupils were very open-minded about the subject area as they had little to base a judgement on. In many ways working on a theme of communication, which complemented the Integrated Studies course, may have been reminiscent of their experience of project work in primary school as they sat around one large table and worked together making name badges, working through a design process which became common to all their CDT projects. Throughout the year, each project was followed through with an emphasis on design work, planning and modelling and I had no difficulty in getting the pupils to work this way. Starting virtually no facilities and equipment may have made the pupils more appreciative when they started to arrive. Each new project was greeted with enthusiasm.

The arrival of the computer caused some excitement because I also had a digitise which enabled pupils very quickly to produce drawing both on the screen and printed. When the Graphics/Technology room was completed, pupils were eager to move in. Pupils easily transferred knowledge and skills from one project to another, one material to another. The new subject excited interest among all pupils. During the first term many older pupils came visiting, curious about the 'new subject' and wondering why they were excluded. Being on two sites with first years on only one site made Craft, Design and Technology clubs impossible to offer equally. At the time the third years were making their option choices, I travelled between the two sites explaining what the subject area had to offer in the way of examination courses, feeling as if I were running a 'road show'. The option booklet available from the ILEA Equal Opportunities Unit, *What's this design and technology?* was very useful. Produced by GATE working party, it has photographs of girls playing a prominent part in CDT activities. The following September we started two full courses in Graphical Communication in the fourth year, one on each site.

By identifying what CDT had to offer pupils and staff we managed some liaison with other departments in that first year. Computerised mural design with a second year Art group, for example, as well as more conventional topic shadowing took place within the Art and Science Departments. From these observations and my previous experience of teaching CDT at a girls' school I evolved the following aims for the discipline:

- to develop designing skills in the pupils to help them exercise their curiosity;
- to enable pupils to formulate their ideas and express them;
- to develop in pupils the ability to relate function to design- finding out and making things work;
- to provide situations where pupils can test, evaluate and ultimately take responsibility for their own actions.

Young people are growing up today with technology as an everyday experience. CDT should therefore help pupils understand and appreciate the world in which they live; help them understand technological language and concepts; and help them enjoy using modern processes and materials as well as learn traditional crafts and skills.

Pupils will have experienced sex-role stereotyping before entering secondary school in toys and games and in activities which give children experience of using machinery or constructional mechanisms. Craft, Design and Technology

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departments have a vital responsibility to develop pupils' confidence with 'tinkering activities': provide a safe and stimulating environment for working; create a welcoming atmosphere; and provide resources and materials which positively affect pupils' perception of CDT.

Because pupils have varied social and cultural backgrounds, projects should provide opportunities for pupils to develop their own interests through individual and group design work and encourage personal research and input into projects. With mixed ability teaching groups it is important to ensure that individual pupils can progress at a pace suitable for them; to build up each pupil's confidence in skills and to develop in pupils a habit of being safe to reinforce this confidence.

The choice of projects followed during that first year was largely determined by the pupils' interests, limited facilities as they became available and an emphasis on accessibility. I was also able to draw on the pupils' experiences in other areas for example, the computer club. Computer drawing was an 'on-going' project initially as only groups of two or three could create a drawing at one time on the digitiser. My aims were to introduce computer drawing as another drawing technique which could be used alongside other media. I also wanted pupils to be confident in using the computer, to achieve successful results quickly, and to take away any misconception about the use of computers.

I asked the pupils to first design their computer drawing on paper. This sketch was attached to the graphic pad of the digitiser by means of a plastic sheet. Pupils then traced their drawing by using the cross and instructions e.g. they could create rectangles, circles, join lines, draw arcs, and draw freehand painting with a range of colours when the drawing was complete. After an initial demonstration, pupils took about twenty five-minutes to complete this. While the computer was being used the rest of the group were learning to model with card as another form of drawing. Pupils have subsequently become accustomed to the computer being used as a drawing tool in their graphics projects, word processing facility and working various 'buggies' for computer control.

Another project, initiated in that first year and subsequently developed to involve construction kits and electronics, was the vehicle project. I asked pupils to design a vehicle in the form of an advertisement with the aim of taking them through the design process from identifying a task, through making orthographic and isometric drawings of it, to cutting lists and modelling it from balsa wood. They were asked to design a vehicle different from anything on the market, give it a name, and to communicate on the poster what was different about it. Needless to say, they came up with and produced some extraordinary names! The project was not only enjoyable, it consolidated many of their graphical skills and introduced a limited (but not limiting) experience of working with wood.

The final project of the summer aimed to encourage group discussion and division of tasks, since much of their work had been individual. It was interesting to see how differently each group worked, from initial planning, drawings and card models through to the final models which were mostly made from balsa wood. We talked about safety mechanisms and materials and the pupils researched very willingly!

Craft, Design and Technology at Elizabeth Garrett Anderson School is developing quickly. In the second year a Deputy Head of Department was appointed and two lower school years were taught in addition to the two fourth year examination groups. During the fourth term of the department's existence, in addition to the Graphic/Technology room, the Engineering/

Technology workshop was completed. In the sixth term, the multi-material workshop was available. A part-time workshop technician was also appointed during that time.

In September 1986, two years after those early days of borrowing rooms and equipment, we started with a fully equipped and staffed department teaching CDT to the first three years, running fourth and fifth year examination courses in Graphics and a combined Science and CDT examination course in Technology for fourth year pupils. The staff also run an after school club and the occasional session for the womens' group.

Accessibility is not just the provision of facilities, tools and equipment. To some extent it is facilitated by the commitment and vision of other members of staff who 'make room' for the subject in a traditional curriculum for girls education. Pupil interaction does not pose the same issue which is prevalent in co-educational lessons as the school is single-sex. External pressures do not seem to affect option choices to a great extent as shown by the full take up of Graphical Communication and Technology courses at examination level.

The department at Elizabeth Garrett Anderson School has been unique in that all the teaching staff have been women, unique nationally and also in the opportunity this has given our newest and least experienced member of staff to develop her own skills within a framework of female role models. The environment is attractive and welcoming, the multi-material workshop having perhaps the most pleasant outlook of any classroom on site.

The department has been democratically run with consensus of ideas for each project resulting in efficient production and use of design and information sheets and overall enthusiasm and commitment for the work. Every project has been reviewed for future application. Pupils' work is well and continuously displayed.

The way ahead at Elizabeth Garrett Anderson School as I see it, is with greater use of computer control and aided design; closer liaison with Science work in the first three years to create valid designing, making and testing situations and a sensitivity to the needs of the pupils within the community.

The holistic nature of good Craft, Design and Technology practice is a vital part of pupils' learning experience. As a primary trained teacher I have worked within the constraints of the secondary curriculum to break down the barriers between subject disciplines. My secondary teaching experience counteracts many assumptions made about girls and workshop activities and I see the growing development of Craft, Design and Technology with primary pupils as a vital part in giving pupils an equal chance of personal growth and development. It is to this end that my own path has taken a turn into initial teacher training of primary teachers with the aim of moving towards greater access for all pupils as early as possible in their formal education.

CLOSING THE COMPUTER GENDER GAP IN SCHOOL

JO SANDERS

WOMEN'S ACTION ALLIANCE

In this paper, I am pleased to present a discussion of the status of computer equity for girls in the United States. I have included: a sample of the evidence for the computer gender gap, the consequences if the level of girls' computer use remains inferior to that of boys, my understanding of the causes of the sex discrepancy in computer use, a description of our national Computer Equity Training Project and how we achieved our goal of equalizing computer use in school, the major lessons I have learned from my research, and finally, implications for the future.

I. EVIDENCE OF THE COMPUTER GENDER GAP

Before 1983 or so, the fact that boys took to the computer in greater numbers and with more enthusiasm than girls was realized by very few people. The attention of educators, parents, and other adults was focused on the fascinating (or, depending on one's point of view, alarming) new machine rather than its user. Whereas computers had commonly been tucked away in data processing offices and a few video arcades before then, the early '80s saw their widespread introduction into areas more visible to the general public: classrooms, homes, even summer camps. Astute observers began to notice that this apparently sex-neutral machine that looked like a television hooked up to a typewriter was not attracting users in a sex-neutral manner.

Even today in 1987, many people still do not "see" the computer gender gap. I have often had the experience of describing the computer equity problem to skeptical educators who later tell me that the conversation prompted them to make an actual count of the students in the computer room. "There were 15 boys and three girls," they say with astonishment. There always were, but they never noticed it before. What one sees every day is often hard to notice.

Here, then, is an overview of the places the computer gender gap can be seen when we know how to look for it. You will notice that for the most part it first shows up at the middle school level, or when children are about 13 or 14 years old.

In School

- In our Computer Equity Training Project, the five middle or junior high schools that participated in our field test had three times more boys than girls using school computers in their free time. The computer elective course enrollment ratio was 2:1 in favor of boys. (1)

- The National Assessment of Educational Progress reported on 13-year-old students who said they took a computer class once a week in 1984: 20.3 percent of the boys and 16.5 percent of the girls. An exception was business applications classes, where girls predominated. (2)

- In a 1984 article about computer equity in the science magazine Discover, writer Gina Kolata described a California survey in which "boys and girls in the fourth through twelfth grade were asked to describe how they would use computers when they were 30 years old... [T]he boys said they would use computers for finances, data processing, and games; the girls thought they would use them for housework. Wrote one sixth grade girl: 'When I am thirty, I'll have a computer that has long arms and that can clean the house and cook meals, and another computer to pay for groceries and stuff.'" (3)

- Researcher Marlaine Lockheed found in 1982 that while 40 percent of the boys at Princeton High School said they used the school computers during their free periods, only 8 percent of the girls said they did. (4)

- Albuquerque (New Mexico) Public Schools found in 1984 that among the K-12 students surveyed, 46 percent of the boys had written a computer program but only 32 percent of the girls had. Thirty-seven percent of the boys but only 20 percent of the girls said they had taught themselves how to use a computer. (5)

- In Henry Jay Becker's most recent (1985) national survey of computers in schools, he found that about two-thirds of secondary schools reported male dominance (defined as more than 60 percent male) in optional-time computer use. More specifically, 75 percent of the schools reported male dominance in game-playing, 50 percent in programming, and 25 percent in word processing. Almost no schools reported female dominance in these areas, except for word processing. (6)

- Betty Collis reported on her survey of 3,000 Canadian students, in which girls say that while women in general are competent at computers, they are much less confident in their own computer competence -- the "we can, but I can't" paradox. The survey also found sex differences in attitudes about computers well established by 8th grade, with boys reporting signficantly more positive attitudes than girls. (7)

- At the end of a second year of intensive computer education, 3rd and 4th grade boys in an upper-income town rated their comfort with computers higher than the girls did (67 percent vs. 36 percent respectively). Moreover, the gap had widened since the first year. (8)

- In the fall of 1986 a concerned parent in another upper-income town surveyed 5th and 6th graders and found that about a third of both boys and girls agreed with the statement, "Mostly boys like computers." The ratio of boys to girls who planned to take a computer course in high school was 3:1, perhaps reflecting the finding that while 86 percent of the boys thought computers would be important to their future, only 63 percent of the girls thought so. (9)

- Dr. Becker asked principals to name the person in each school who was considered the "primary computer-using teacher." Sixty-seven percent of elementary school principals named a woman, while 44 percent of the secondary school principals named a woman. (10)

- Researchers Irene Miura and Robert Hess showed middle school students a list of software titles and asked them to rate each title on a five-point scale as being of more interest to males or females. The students felt that 35 percent of the titles were of primary interest to males while only 5 percent were of primary interest to females. (11)

- In 1986, men were two-thirds of district computer coordinators across the United States. They earned 54 percent more than their female counterparts, partly because women were more likely to hold part-time positions -- $37,400 vs. $24,300. (12)

- In 1982, women earned 33 percent of the bachelor's degrees in computer and information science, 23 percent of the master's, and 10 percent of the Ph.D.'s. This is the greatest relative decline for women from bachelors' to doctorate for any field except law, including mathematics, physics, and chemistry. (13)

At Home

- In our Computer Equity Training Project, five times more boys than girls used their home computer more than any other family member. Their parents bought twice as many computers for sons than for daughters. (14)

- In the study of the 3rd and 4th graders mentioned above, 51 percent of boys who had computers at home said they spent an hour or more every day using it. The figure for girls was 35 percent. (15)

- There is a study of a 1983 student programming contest in Kentucky. Fifty-one percent of the male students who participated and 31 percent of the female students had home computers. Even more striking, 190 boys and 29 girls participated in the contest. (16)

- According to an advertising executive who specializes in the computer field, women are only 15 percent of the home computer market. (17)

In Summer Camp

- Irene Miura and Robert Hess surveyed 23 computer camp directors in 1983. They found that female enrollment declined with several factors: age -- 30 percent for elementary grades to 24 percent for high school grades; "curriculum" level -- 27 percent for beginning programming to 5 percent for assembly language; and cost -- 32 percent for camps costing under $100 to 15 percent for camps costing over $1,000. (18)

In the Media

- A few years ago I analyzed four large-circulation computer magazines for their treatment of women and men. Men far outnumbered women in the feature and advertising photographs and as the subjects and authors of articles. (19)

- A more detailed analysis of pictures in mass-market computer magazines was recently conducted by M.C. Ware and M.F. Stuck. They found that the ratio of men to women was nearly 2:1 in the illustrations. Women were usually presented as clerical workers and/or sex objects, while men tended to be managers, experts, and repairers. The only people shown as rejecting the computer or as sex objects were women. (20)

I am not aware of any studies conducted on television computer commercials, but by and large most commercials seem to be aimed at a male market. The demonstrators of the computers are usually male (except for the sex objects) and they are selling to men or to parents for their sons.

In the Workplace

- According to the U.S. Department of Labor, women in 1984 were 34 percent of computer programmers, 30 percent of systems analysts, 13 percent of electrical and electronic technicians, 10 percent of data-processing

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equipment repairers, and 7 percent of electrical and electronic engineers. On the other hand, they were 64 percent of computer operators and 92 percent of data-entry keyers, both low-paid occupations. (21)

- Examining gender segregation in computer-related occupations, Myra Strober and Carolyn Arnold conclude that despite the recent origin of these occupations, "they are not gender-neutral. The computer field was sired by the fields of mathematics and engineering, and the newly born prestigious and technical jobs quickly took on the gender designation of the parent fields." They also found that "the higher the status and pay of the [computer-related] occupation, the more white men were overrepresented compared to their representation in the labor force as a whole..." (22)

Miscellaneous Other Places

- According to San Francisco newspapers, women bought 45 percent of the new cars but only 2 percent of the microcomputers sold in the Bay area in 1982. (23)

I have seen no studies or figures on the relative presence of males and females in video arcades, computer trade shows, and computer stores, but my own observations as well as conversations with participants lead me to estimate at least a 3:1 ratio in favor of males. It looked like there were about 90 or 95 males for every female at a computer trade show I recently attended. Video arcades seem to attract more girls than that, but a close examination reveals that most of the girls there aren't there to play the games -- they're looking over the shoulders of the boys who are.

I understand there are figures on male/female computer magazine subscribers and that the subscribers are heavily male, but I have not seen the actual studies.

It is therefore safe to say that the computer gender gap is society-wide. What are the implications for girls in school today?

II. CONSEQUENCES OF THE COMPUTER GENDER GAP

Girls who are allowed to avoid the computer as adolescents can expect to pay a heavy price as adults, particularly in terms of their occupational futures. This is not the place for an extended discussion of women's status in the labor market, but a few facts from the U.S. Department of Labor's Women's Bureau will tell the story adequately:

- Nine out of ten girls now in school will work for pay as adults. Another version of this fact is that only five percent of American families now fit the traditional profile -- breadwinner father, homemaker mother, and two children.

- Today's schoolgirls can expect to spend 29 years in the labor market. This is longer than they will spend raising their children.

- The average woman must work nearly nine hours to earn the same amount of money the average man earns in five hours.. American women today earn 64 percent of what men earn -- in large part because 80 percent of women are concentrated in low-paid, female-intensive jobs.

- Sixty-five percent of women are now in the labor force, and a very conservative estimate is that two-thirds of them are there from economic necessity, to support themselves or their families. This is, of course, the same reason men work.

- Women are the sole support of 17 percent of all American families, and this figure is growing rapidly in part because half our marriages end in divorce and in part due to the dramatic increase in babies born to unmarried mothers.

The point of these statistics is that we can say with certainty that most girls in school today will need to work for a living. They will also have to earn far more than "pin money" if they and their families are to live decently.

Occupations that directly involve advanced computer skills pay quite well. In 1984, the average computer programmer earned about $26,000, while the average systems analyst and the average college or university computer science teacher both earned over $31,000. Even electrical and electronic technicians earned nearly $22,000. These figures compare with an average clerical salary of about $14,000 per year, a little more than $18,000 for social workers, and nearly $21,000 for librarians. In other words, computer-related jobs pay significantly better than female-intensive jobs requiring equivalent amounts of education.

But speaking only of directly computer-related occupations is too narrow a focus. The vast majority of people who use computers are not programmers or electronics engineers, but rather drafters, businesspeople, researchers, hospital technicians, bankers, architects, product designers, and others in an enormous range of occupations who use computers as a tool in the everyday course of their jobs. When today's girls grow up without computer skills, will they eliminate all these occupations from consideration as career possibilities?

I think we also have to consider the computer as symbol. To the general public, the computer in a sense "stands for" technological advances that are now more or less in the development stage: laser technology, robotics, genetic engineering, artificial intelligence, and others. There is no question but that they will grow in importance, numbers of people involved in them, and impact on our lives. The exclusion of women who associate these fields with the computer they avoided as a teenager will be felt for generations. Beyond this, it cannot be healthy for an increasingly technological society to have its female half in ignorance of technology. Ignorant citizens cannot make informed public or private decisions on technological issues.

It is clear that knowledge of the computer and generally positive attitudes about the computer are desirable. Why, then, do we see such a pervasive computer equity problem?

III. CAUSES OF THE COMPUTER GENDER GAP

Girls live in the same world we do. Their eyes work the same way. Just as we do, they see the preponderance of males in the computer room at school, their brothers and fathers using the home computer, boys in the video arcades, men in the computer stores and featured in the print and television ads. Their conclusion that computers aren't quite a feminine thing to do is hardly surprising. In other words, the society-wide evidence of the computer gender gap leads girls to remove themselves from the ranks of computer users, thereby creating more evidence for other girls to act upon. This is of course a "vicious circle" pattern.

I believe this is also why we tend to see the computer gender gap emerge at the age of puberty, since this is the developmental stage at which children concentrate on defining their interests and activities in terms of adult sex roles. Early adolescence is when athletic girls begin to dislike gym class. It's when girls who have always been good at math and science begin to feel they're no good at these subjects. It's fascinating to me that the only two school districts I've heard of where the computer gender gap shows up earlier than the middle school grades are both upper-income communities: it's possible that economic privilege pushes these children to grow up sooner than others.

The male/computer association is not **caused** by school personnel, but by girls' accurate observation that in a wide range of environments mostly males use computers. However, schools' failure to challenge the equation maintains it. In fact, the gap can widen with age when official silence is understood as official approval. When the deck is stacked to begin with, treating unequal entities evenhandedly cannot possibly lead to equal results.

Beyond this basic cause, we have been able to identify a number of factors which may well reinforce girls' assumption that computers are not for them:

- **Math.** Computers are used more frequently in math class than any other regular academic subject except computer class. We already know about girls' avoidance of math.
- **Machines.** Computers are seen as machines -- complex, mystifying, delicate, and foreign machines. Girls are not brought up to tinker with machines.
- **Software.** Much recreational software and some educational software is sexist. There's more on software later in this paper.
- **Adults' Assumptions.** When teachers and parents assume that boys are "naturally" more interested in computers than girls because this is what they think they see, they convey their assumption verbally and behaviorally, subtly or unsubtly. This becomes a self-fulfilling prophecy.

However, you may be thinking, boys and girls in the elementary grades tend to enjoy the computer pretty much equally. Don't girls who are accustomed to using the computer for many years resist the pressure to stop? Some do, of course. But there are many ways in which schools can discourage existing female computer interest without realizing it:

- **First Come, First Served.** Most schools handle insufficient computer supply by letting students themselves regulate demand. A "first come, first served" system allocates the resource to the most highly motivated students, usually boys. Since girls are not generally socialized to be assertive or to insist on their rights over boys' claims, the stacked deck remains unchallenged.
- **Competing Interests.** We have often been told by observant teachers that for the most part girls who like the computer tend to have many other interests as well, but boys who like the computer tend to have few other academic or social satisfactions in their lives. This is, of course, the popular image of the "computer nerd." As a result, girls have less time than boys to spend at the computer, and they avoid the computer for fear of resembling "computer nerds".

- **Unorganized Computer Time.** Unorganized free-time computer use, such as after school, usually encourages users to follow their own individual software interests. Many early adolescent girls prefer group activities to solitary ones.

- **Computers Without Instruction.** Because young girls in the United States are usually socialized to follow rules and are not often encouraged to tinker, explore, or invent on their own, many girls tend not to be comfortable figuring out how to use software or hardware on their own. This would account for teachers' observations that boys are likelier to play with a computer for its own sake, just to see what they can make it do, and that girls are likelier to be concerned about breaking the machine. Simply making unfamiliar hardware and software available for student use without instruction, particularly complex software such as applications (data bases, spreadsheets, etc.) or programming languages, therefore impacts more heavily on girls.

- **Home Responsibilities.** If there are younger children to be cared for after school or other home responsibilities to be taken care of, parents are more likely to put girls in charge than boys, thus reducing girls' opportunity to use the school computers after hours. Some parents, believing that the unstructured after-school environment poses a danger to the safety and/or reputation of their daughters but not their sons, don't allow daughters to remain in school after classes are over for the day.

It's no surprise that old socialization issues crop up in the new environment of the school computer room: it is the nature of sex-role socialization to shape our responses to the world throughout our lives and in new environments. But what is learned can be unlearned, and this is the basis for the success of our Computer Equity Training Project.

IV. THE COMPUTER EQUITY TRAINING PROJECT

Women's Action Alliance was funded by the Women's Educational Equity Act Program, United States Department of Education, from October 1983 to February 1986 to research the computer equity issue and to develop and test school-based strategies for increasing girls' computer use. The outcome of the project was a book for educators.

From the outset, we focused on **optional** computer use, such as in free time before or after school or in computer elective courses. Aside from the fact that since most schools have roughly equal numbers of boys and girls any required course merely mirrors that ratio, freely chosen computer use is the best barometer of continued interest in and involvement with the technology. We also focused on 7th and 8th grades (13-15 years old), since research had pointed to this level as the one where the computer gender gap usually shows up first.

After a literature review and personal contacts with many educators across the country, we developed what we called our "speculation list" of possible causes of the computer gender gap. We took this list to the teachers and administrators of three schools we selected to participate in the developmental pilot test phase of the project. (The schools were Franklin Junior High School, Whitewater, Wisconsin; Waldport Junior High School, Waldport, Oregon; and Mount Hebron Middle School in Upper Montclair, New Jersey.) We told the team in each school that since frankly no one was sure of the cause(s), they should choose those which in their experience were the likeliest culprits and devise strategies to counteract them.

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The three schools implemented about four to six strategies each, among them reserving the computer room for girls only on one or two days per week, targeting parents with computer equity information, rearranging the computer room furniture to permit more student interaction, a greater emphasis on computer graphics, a switch from BASIC to Logo in the elementary computer course, and others.

Informal results -- simple record-keeping and teacher reports -- indicated that most of the strategies they tried seemed to encourage more girls to become interested or retain their interest in computers. This information, plus an ongoing review of the literature and continued contacts with educators nationwide, went into the field test draft of our book, which we called *The Neuter Computer*.

Unlike the developmental pilot test, the field test was designed as a rigorous field experiment. Of the five schools chosen to participate, three became experimental schools (Nobel Junior High School in Los Angeles, California; Gering Junior High School in Gering, Nebraska; and Camel's Hump Middle School in Richmond, Vermont). Lamar-at-Trenton Middle School in McAllen, Texas became the control school, and Cumberland Middle School in Cumberland, Rhode Island became the attention control school. Student computer-use records were kept at all five schools.

There were three interventions: *The Neuter Computer*, a faculty workshop in computer equity conducted by project staff, and a telephone call every two weeks to ask about progress and maintain interest. The experimental schools received all three interventions. The attention control school received the workshop and the calls. The control school received no intervention at all.

As in the pilot test, each experimental school formed a team of teachers, administrators, and in some cases parents, to select four to six varied strategies from *The Neuter Computer* and carry them out. In doing so, they followed planning and implementation guidelines contained in the book. The teams chose a variety of strategies, including a computer graphics mini-course, having a language arts teacher use computers in class, a girls' computer committee, recruiting female computer room supervisors, presenting a formal in-service session on computer equity to the entire faculty, holding a "computer open house" for parents with emphasis on the equity dimension, scheduling separate boys' days and girls' days in the computer room after school, producing the school newspaper on a word processor, and others. There was obviously no team (and no strategies) at the control school, and while the project staff invited the attention control school to form a computer equity team they did not do so.

The results of the one-term (four to five months) field test exceeded not only our expectations but our hopes. The control school, with no intervention, had no increase in girls' computer use during the term. The attention control school, which had received a workshop for faculty and reminders of the project every two weeks, registered a 14 percent increase. The experimental schools, however, with the workshop, the bimonthly calls, and *The Neuter Computer*, increased girls' computer use an average of 144 percent over the term. Whereas girls were a quarter of the optional computer users at the beginning, they were half of them at the end. (24)

Co-author Antonia Stone and I revised the field test draft of *The Neuter Computer: Computers for Girls and Boys*, which was published by Neal-Schuman Publishers late in 1986. It contains an overview of the computer equity issue; 56 educationally sound computer activities arranged by software type (i.e., data bases, programming languages, graphics, computer-

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based instruction, etc.) that are especially attractive to girls; 96 computer equity strategies that can be carried out by teachers and staff, administrators, parents, and students themselves; guidelines on planning a computer equity program in a school; forms and questionnaires; and extensive annotated resource listings. As far as we know, it is the most comprehensive book yet published on the subject of computer equity for girls.

V. MAJOR LESSONS LEARNED

We have learned a number of major lessons from our research, our contacts with teachers, administrators, girls, and other researchers, and our pilot and field test experiences. Here are those I consider most important.

Target Girls Clearly

Because of girls' understandable association of computers with male, any effort to encourage their computer use must be very, very clear. In a computer context, girls will translate "students" or "all students" as meaning "boys". They'll even translate "girls and boys" as "boys". To make sure girls understand you are talking about them, you have to say COMPUTERS ARE FOR GIRLS. This applies to informal suggestions ("Carmen, come here -- I want to show you something on the computer") as well as more formal strategies ("We especially want a lot of girls as computer assistants").

Moreover, targeting teachers or parents on the theory that they will influence girls tends to be significantly less successful than targeting girls directly. Several schools in our project reasoned that it was necessary to improve teachers' own familiarity with the computer before teachers could encourage girls. While fine in theory, the reality was that teachers' computer competence became an end in itself. Teachers were reluctant to begin using computers with actual students, apparently feeling that they weren't yet expert "enough". Administrators would therefore be wise to build a "take the plunge" date into computer training for teachers. Similarly, schools that offered computer instruction to parents while talking to them about computer equity for girls assumed that the equity part would trickle down to their daughters. There is no evidence that this actually happened. I am not saying that you shouldn't bother targeting parents or teachers, but be sure that the method for their encouragement of girls' computer use is clearly spelled out and scheduled.

Target Girls in Friendship Groups

Developmentally, adolescent girls are intensely social creatures. One of the heartening things we learned when we asked girls about their computer preferences is that they don't, contrary to popular opinion, stay out of the computer room because the boys are there. Instead, they stay out because their friends, who at this age are likely to be other girls, are not there. This means that you target girls in friendship groups, not individually. A girl can't worry that her friends will think she's weird to like computers if her friends are right there with her in the computer room. And in turn, ask the girls in the computer room to bring other friends with them next time. Make the teenage herd instinct work for you, for a change.

I think this explains the clear success of such computer equity strategies as girls' day/boys' day, or a girls' computer committee, or a computer minicourse especially for girls -- by definition, girls are there in friendship groups. I urge you, however, to phase out such strategies as soon as girls' computer interest is firmly established. The last thing we want to do in any educational equity endeavor is to establish sex-segregated educational programs.

Make Computer Use Useful

While naturally not true of **all** girls and **all** boys, a recurrent theme is that while boys seem content to "play around" with the computer and explore its capabilities with no particular goal in mind, girls tend to want the computer to do something useful for them. This can mean making their homework easier or better, or learning class material better, or enabling them to do non-school things better. For example, one experimental school reported that a good female recruitment tool was to show girls how "Print Shop" could be used to make party invitations or greeting cards. When the cards were showed off at the bus stop many new girls were attracted to the computer room.

Consequently, it will help if you stress the utility of the computer. Choose and present software in terms of how it will help girls do what they need or want to do.

You Can Start Low, But Don't Stay There

Some people have trouble with the idea of using "Print Shop" to attract girls to the computer. They'd rather use the computer for higher-order thinking skills, partly because this is a more sophisticated use of a sophisticated machine and partly because "Print Shop" strikes them as an insult to girls' intellectual level.

While I sympathize with these attitudes, I'm old enough to have lost some of the uncompromising purity of my younger years. If "Print Shop" proves intriguing and if programming doesn't in getting girls interested in computers, then I say go with "Print Shop". It seems to me, moreover, that starting where students are and then moving them on to where they need to be is elementary pedagogy.

Two caveats, however. First, don't assume **all** girls will respond only to the simplest computer uses. There will surely be some who would be bored silly by "Print Shop" but fascinated by programming, and to assume otherwise is to fall into the sexist trap we're trying to avoid. Second, don't let girls stay at an elementary computer level once they're there. There's no point in going to the trouble of increasing girls' computer use if all they'll have to show for it is a few party invitations. Move them on to more advanced computer skills as soon as possible or you'll once again be running a dual system: advanced for boys and elementary for girls.

Software

Software isn't necessarily a problem. Applications -- word processing, spreadsheets, and the like -- are by definition sex-neutral. Many simulations, such as those involving volcanic explosions or political scenarios, make the student the decision-maker and are also sex-neutral. And certainly there's nothing inherently sex biased about drill-and-practice exercises in grammar or arithmetic.

In school settings, sexism in software, where it exists, is usually subtle. ("Recreational" software for home use is often extremely macho.) Educational games in which the police officer or the business executive on the screen is always male are sexist in the aggregate: surely we can't say they can **never** be male, but they shouldn't **always** be. Similarly, there's nothing wrong with a program that rewards correct answers with a football sailing over the goalpost; it's the accumulation of male-identified themes that tells a girl she's out of place. It's quite easy to check out your software with this consideration in mind.

Another issue is violence in software. There is increasingly convincing evidence that many girls don't find this as attractive as many boys do, and to the extent that software features violence it serves to discourage girls' computer interest. A number of educational programs have unnecessarily violent titles, such as "Math Blaster" or "Word Attack". Others reward a right answer by showing a missile blowing up an alien spaceship. Since I have yet to find one educator who thinks that a large dose of violence, on the computer or elsewhere, is good for students, I can't understand why anyone permits violent software in a school building. It won't do to say that violent computer games can only be used in students' free time: do we let children read magazines on sado-masochism in the school building only after hours? In my opinion, violent software has no place in school at any time for girls or for boys. And to the extent that you can educate parents about software choices for their home computers, try to get the message across to them, too.

Sex of the Teacher

I am happy to tell you that your particular plumbing system has little effect on girls' computer use. The national surveys conducted by Henry Jay Becker that I cited earlier show that women are about half of the computer teachers in the United States, and yet there's a sizable computer gender gap nearly everywhere. The schools we worked with in the Computer Equity Training Project had to show a computer gender gap to participate in the project, yet the sex ratio of the computer teachers was roughly equal. The most that can be said is that all things being equal, there is a slight advantage to having a female computer teacher.

Far more important than the sex of the teacher is what the teacher does. A teacher, male or female, who assumes that girls "aren't interested" in computers and behaves accordingly will probably widen the computer gender gap, since such a teacher makes it easy for girls who aren't sure about the computer to decide it's not for them. A teacher, male or female, who is aware of girls' computer avoidance and takes steps to overcome it will narrow it and can eliminate it entirely.

VI. IMPLICATIONS FOR THE FUTURE

Although I hope this paper has been informative, there is in fact much we still do not know. Computers are simply too new.

We do not know whether a girl who is lucky enough to have parents and teachers who enthusiastically encourage her interest in computers from a very young age is likely to change her mind when she reaches adolescence. To put this question another way, will the positive influence of her parents and teachers be sufficient to counteract the negative influence of the rest of society which continues to send her messages associating computers with males?

We do not know whether an adolescent girl who avoids the computer will grow up into a woman who perceives the occupational value of computer skills and learns them at that time. Since her computer avoidance is based on reluctance to cross the sex-role line in the crucial teenage years and therefore has a substantial emotional component, will she be able to approach the computer-learning decision on a different and more rational basis? I am well aware that many adult women are currently taking computer

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education courses, but none of them developed negative feelings about the computer in their youth because there were no computers when they were teenagers.

We do not know which computer experiences and skills lead a girl to enter science and technology careers later. Indeed, we don't even know for sure if computer experiences and skills during adolescence are a strong factor, although common sense would say yes. If so, is simple enjoyment of the computer -- "Print Shop", let's say -- as an adolescent all a girl needs to start her on the path of a technological career? Or does she need to experience what the computer can do on a more advanced level? Naturally, these questions apply at least in part to boys as well.

Research -- and time -- are needed to answer these and other important questions. Although I hope that in ten to twenty years they'll be settled, the millions of girls in school today can't wait for the answers. Before then, prudence compels us to take all the affirmative computer equity steps we can just in case they turn out to be necessary. Wasting a little time and effort now is much preferable to wasting lifetime careers and talent later on.

When all is said and done, computer equity is really very easy to accomplish. What we have learned is that when adults actively counteract the computer/male message, the intrinsic usefulness, enjoyment, and fascination of the computer takes over to change girls from computerphobes to computerphiles. Moreover, there's no one right way to do it: almost anything that piques girls' interest, and our book lists 96 strategies from the effortless to the martyr-level, is the right way to do it.

However, the fact that something is easy to do doesn't guarantee that it will be done. This is clearly the case with computer equity. First, many educators still **look** at fifteen boys and three girls in the computer room and do not **see** a computer gender gap. Until they see girls' low level of computer use as a problem and not as something natural (in their genes or wherever), there is little chance of remedying it. Second, some educators who become aware of the computer gender gap are uncomfortable with the necessity of openly targeting girls with computer equity strategies: "We don't discriminate here." This is a very nice attitude, but as we have seen evenhandedness favors the stacked deck and guarantees the continuation of the existing sex imbalance. And third, even when an educator is willing to implement computer equity strategies aimed specifically at girls and is successful at closing the computer gender gap in her or his classroom or school, what happens when next year's teacher fails to counteract the computer/male messages that continue to reach girls from so many sources in our society?

I therefore suggest that the crucial question facing us now is not how to achieve computer equity for girls -- we know how. It is rather whether we choose to. And that is neither simple nor easy.

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SWIMMING UPSTREAM?

Women in Natural Science and Technological Research. Strategies for Recruitment

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Are women aliens in the male dominated world of natural science and technological research? If we consider that women constitute 7 % of the permanent staff in the natural sciences and 1 % in technology at Norwegian universities that does not seem to be such a farfetched assertion. This was one of the realities that confronted NAVFs Secretariat for Women and Research when it began its work in the autumn of 1982. The Secretariat's duties were to initiate, coordinate and disseminate women's research and to work to increase the recruitment of women to research. Encouraging those who were already there to continue their efforts was also one of the aims of the Secretariat. As a body under the auspicies of the Norwegian Research Council for Science and the Humanities, NAVF, the Secretariat had responsibilities for the same subject areas as the Council, i.e. the humanities, medicine, the natural and social sciences. Later the Secretariat also took on some responsibilities for technological subject areas.

In this paper we should like to present some background information about the reasons for establishing the Secretariat. We shall say more about our beginning work with the natural sciences and technology and mention the strategies we have used in trying to accomplish our aims. In conclusion we would like to share some of our experiences, reflections, and if possible, our visions.

Background

In the mid-1970s NAVF began work to encourage women's research and women researchers. The background for this was the knowledge that women were weakly represented in most areas of societal life. Formal equal status measures had not led to real equal conditions. There was widespread political consensus that this was unfortunate. But it was difficult to find remedies and good solutions to these problems as long as the causes behind them were, and in part still are, obscure.

Within the university and research system it was particularly students and young researchers who demanded more knowledge about and better insight into the past and present situation of women in order to be able to understand why things are the way they are today. It has also been said that large areas of cultural heritage are disseminated incompletely by schools and society because they are treated with the tacit premise that men set the norms, are the "normal". Within NAVF these signals were taken seriously by two of its five research councils, the Council for Humanistic Research and the Council for Social Science Research. Those in the humanities decided to support women's research through a stipend programme during the years 1977-1980, while the social scientists established the Secretariat for Women and Research for a period of five years from 1977. After re-evaluating the situation of women's research and women researchers, NAVFs board decided to establish a new, interdisciplinary secretariat for women's research and and women researchers covering all the subjects for which NAVF has responsibility. It was established for a period of three years, this was then extended for a year and from 1987 extended again for a further four years.

During this last period, until 1990, much of our work will concentrate on the recruitment of women to medicine, the natural sciences and technology. The decision about an interdisciplinary Secretariat was also in accordance with the Government's Action Plan for Equal Status (1980-1981) where the importance of a secretariat for women and research was emphasized. We would like to stress that the continuous positive and audible support of central authorities have been of decisive importance for the Secretariat's work.

Female recruitment - A place to start

When we began to work in the autumn of 1982, none of the employees at the Secretariat had experience with natural science or technological studies and research. We were therefore totally dependent upon connections to persons and groups who belonged to these communities and who were sympathetic to our goals. The strategies to be used had to be developed jointly. Furthermore, we were also dependent upon building up a national network of individuals and groups who above all could support this work within their own subject areas and university administrations, but who could also function as a link to the Secretariat. Attempts to influence central authorities had to be our task.

We began by inviting some of the female natural scientists we knew to a meeting. Our first intention was to survey the communities and the problems they possibly had and we hoped that those assembled would put forth and discuss ways in which our work could be continued.

We shall mention a few of the characteristics of these communities:

- few female employees, few female students and decreasing participation at higher levels
- "exploitation" of the few female employees such that they are often committee and panel members and therefore have little time for their own work/research
- women often choose other and less prestigious study streams than men.

After this meeting we were a little better prepared to continue. An important partner has always been NAVF's Council for Natural Science Research where we found funding, human resources and scientific expertise. The Secretariat followed up with different kinds of other arrangements such as meeting academic supervisors, jointly arranging GASAT II in 1983 (Girls and Science and Technology) and a national conference for women in natural science in 1985. We met equal opportunity committees and girls' groups, we participated in international and national seminars where this was a topic, we lobbied central authorities, etc.

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Further work - strategies for implementation

We were aware from the beginning that we would be working on tasks with little prestige and that our work would involve many frustrating experiences. Therefore it was necessary to develop strategies for implementing and achieving goals and some of these points became clear very quickly. We were however not always able to follow our own precepts. As good advice can be useful for others who work with equal status problems we would like to mention our most central experiences and maxims here:

1. Thorough documentation and preparation
2. Get to know as many aspects of the problem as possible
3. Have a broad and positive approach
4. Legitimate your interests, causes
5. Use clever and unorthodox information channels (visualize, think "the opposite")
6. Use alliances at all levels (decentralized networks)
7. Use resources where you think you will achieve most. (Do not prioritize people who are already "saved", don't think that you can save them all.)
8. Prioritize certain tasks
9. Follow up - keep promises

Earlier we mentioned some of the individual initiatives we have undertaken. Here we would like to continue by selecting some of the arrangements and other measures which have contributed to building a basis for further work.

From the Secretariat's beginning, the Council for Natural Science Research participated in NAVF's general equal status work. In practice this meant a few special measures for women, such as technical assistance for recruits, moderate positive discrimination for women in the distribution of educational stipends and small funds for so-called environmental measures (GASAT II, for example, received 50,000 NKr.). The Secretariat tried to build upon these measures and suggested stipends for female students who were continuing their educations in physics and mathematics. This suggestion was accepted and put into practice. In order to have the widest possible survey of women doing natural science research in Norway, the Secretariat felt a need to arrange a national conference where one could discuss recruitment and incitement problems and where individual scientists could have the opportunity to present their research to other women. Trying to get funds for the conference was quite difficult. There were few who felt that such an arrangement was relevant, but when the financial aspects were clear and we could continue with the invitations, interest in participating was "enormous". Approximately 100 women and some few men contributed to making it a successful, and in our eyes, decisive arrangement. The conference took place early in the autumn of 1985 and in many ways can be characterized as the start of a rather comprehensive and powerful consciousness raising process in the scientific community.

Parallel with preparing the conference, the Secretariat did a large evaluation of "NAVFs Support to Female Researchers and Women's Research - Tasks and Organizations after 1986". This evaluation included four scientific fields and its aims were as follows: to evaluate the situation of female researchers and women's research, to suggest how work with areas particularly pertinent to women in specific scientific fields should be continued, and to investigate which types of organizational models would best achieve there aims. The report about the natural sciences suggested several measures at different levels. Central among these were the earmarking of positions and regulations for regular research terms for women in tenured scientific positions. These were put forth under the assumption that the Secretariat would continue and that a consultant position with special responsibility for the natural sciences would be established.

In various ways this report was later seen to be a very useful instrument. Not least, it was often used as documentary material, but perhaps its greatest importance was that it was used as a basis for carrying out many measures. Other than the fact that many of the suggestions which were then put forth are now today's realities, this report also pointed out the tasks and responsibilities that individual institutions and authorities have and should have in the future.

With a few substitutions and some new members, the group which worked on the report about the natural sciences today continues to be the Secretariat's permanent reference group for this field. It was constituted on the basis of scientific, geographical and hierarchical diversification. This group meets often and has already managed to present a plan of action for the field.

We would further like to mention that we have prepared a survey where approximately 170 female natural scientists and some technologists present themselves. This should support the following goals:

- be a basis for a network of female researchers
- survey possible lecturers, seminar teachers and supervisors
- survey female expertise in different fields
- female students will be able to contact specific people for advice, make contacts and receive supervision. It will also be useful to journalists.

This survey has already been very helpful for the work of the Secretariat and others.

Of other measures we would like to mention the importance of the GASAT conference and the material published in connection with it for our work. Through GASAT the Secretariat as well as the scientific community have had the opportunity to get a lot of information. It has been easier for us to understand and to tell others about the psychological and organizational mechanisms and barriers which hinder women in trying to get and obtain top positions in the natural sciences and technology. Without epistemological knowledge this work would be hopeless. Among other things, several articles and three special issues of our journal Nytt om kvinneforskning (News about Women and Research) have been devoted to women doing natural science research. That this type of material is interesting can be shown, for instance, by the great demand for these three special issues. To conclude this part of the paper we would like to mention some of the larger projects which the Secretariat is working on and which will be important contributions to our future work. One is a comprehensive research project about employment procedures and equal opportunity at Norwegian universities and colleges during the period 1979-1984, under project leader Elisabeth Fürst. The other is an alternative women's research report (an alternative "White Paper") under the direction of Drs. Bjørg Aase Sørensen and Tamar Bermann.

The primary aim of the "employment procedure project" is to investigate the extent to which there is concealed discrimination against women during the evaluation and employment procedures for academic positions. Are "patterns" of employment for vacant positions the same for both sexes? Thus far the study shows that competition for positions in all fields is greatest when both sexes apply. Women have a tendency to stay considerably longer in the queue than men when they are applying for permanent university positions, e.g., in the natural sciences there are 5.4 applicants per position when both sexes apply and 3.8 applicants when only men apply. Furthermore, women's chances of obtaining permanent positions in the natural sciences and technology, are noticeably worse than men's. During the 1970s and 1980s there was a difference of 6 percent in the gender distribution of those who obtained positions. As an illustration, during the period 1980-1984, 18 % of the women applicants obtained permanent positions versus 24 % of the men. (An English summary of this project will be issued.)

The primary purpose of the alternative research report will be to evaluate how women's interests can be incorporated into future research, both within a subject area and organizationally, particularly in relation to the fields which are officially being prioritized in Norwegian research. The analysis of consequences is a key concept in this project. It is incomprehensible and a challenge that official priorities for Norwegian research are set within areas where the percentage of women is absolutely lowest, such as, biotechnology, oil and petroleum research, information technology/ telematics.

Experiences - reflections - the future

During our work with attempts to recruit more women to the natural sciences and technology, we have had many positive experiences, especially in relation to increasing understanding and contributing to making things more clear to research policy administrators and women themselves. The question of bringing in "female resources" has become a reality not least because of the expected recruitment crisis in, among other areas, the natural sciences where there is a skewed age distribution of scientific personnel. We have experienced that many of our suggestions have been put into practice and we receive many positive signals about our work. On the other hand, we acknowledge that there is relatively little that a small Secretariat of four persons can achieve. In many ways the communities are responsible for, and must be responsible for, the most important efforts, and in good female tradition there will have to be a lot of unpaid labour. Those of us at the Secretariat function above all as the creators of ideas, instigators, inspirators and coordinators.

We have also learned that an open approach is one of our utmost concerns. Trust between the Secretariat and research communities is a precondition for being able to make progress and to cooperate about strategies and measures. We know that we have not always been so lucky in such matters. This, in turn, has led to misunderstandings, resentments and extra work. At the earlier mentioned conference in 1985, there were, among other things, great differences of opinion between natural and social scientists. Social scientists contribute very importantly to knowledge about women in the natural sciences and technology. But the concepts, descriptions and analyses they use are often thought not to be relevant or adequate by the women to whom they are applied. It would be ideal to establish and develop a dialogue between these two groups. Both groups need to cooperate and to challenge each other in a constructive way. Without doubt this would also be a great challenge to the Secretariat's future activities. We would however like to emphasize that one should be aware of and respect differences in experiences and opinions which are expressed by women themselves also within the same research field. The premise for starting such a dialogue, however, is that one admits that the low number of women in science is a problem for the scientific community and for society as such; and not just a problem which concerns a few individual women.

There are no well-proved strategies for increasing the percentage of women in these fields. There is also no consensus about what these figures conceal, or what male dominance expresses. There are however many experiences of and analyses about the importance of male dominance for everyday research and scientific results. There are many stances, from those who deny that male dominance is of any importance at all to those who think that the patriarchal system is a total part of the way a subject is constituted, its content and organization. Female epistemology is a concept which (provisionally?) is rejected by most, but accepted by some. In conclusion, in order to illustrate the noticeable controversies, we will refer to two articles from a special issue of Nytt om kvinneforskning (4/86) - "Male dominance - more than numbers?".This concerns the opinions of a psychologist and a biochemist about the natural sciences, the place of women in them and the strategies that they think are necessary to achieve greater female participation. Both are researchers and both are very concerned that more women should enter these fields. Some think that these two women disagree greatly, others think that they complement one another. Citations will illustrate their different approaches. We would like to leave it to the reader to evaluate the extent to which their analyses and strategy suggestions are relevant: "Male dominance is the word for social processes in research environments which are suitable for keeping women down and out", according to the psychologist and female researcher Hanne Haavind. Furthermore, she emphasizes that research communities will strongly resist the disclosure of male dominance. "The most effective way of keeping women down and out is to think of the problems women have as their own problems and in consequence not as problems of the research community. Who is then a knower of truths? Many women in natural science research point out that they have never experienced any form of male dominance and that they have never felt discriminated against. Is it possible that a process which many women never notice, nonetheless still exists? In such cases, the lacking ability to experience discrimination can itself come about because all possible problems one might have are seen as one's own. The women who are most successful are perhaps those who are both obedient and prolific." Hanne Haavind has a set of strategies which she thinks should be followed in order to achieve something. The first is to introduce special measures to develop scientific expertise among more women. Women themselves must bring forth these measures, work to have them accepted and follow them up in practice. The other strategy to increase women's power in the world of academia is that women must increase their knowledge about research policy power structures in order to be able to participate in them. And they must increase their efforts in those areas which are most central to research policy. A third strategy consists in challenging existing paradigms in the natural sciences. She thinks that is is possible to set up a feminist critique here on the basis of historical, sociological and scientific theoretical perspectives. Last not least, she thinks that women must work together cooperatively - across disciplinary boundaries.

In contrast, the biochemist Ruth Kleppe emphasizes that the person and sex of the researcher who brings forth results are uninteresting and not important for the ideal goals of research, which are to increase our total knowledge about the natural sciences and technology. On the other hand, she thinks that the way in which research results are used and the fields which are prioritized for resources can possibly be evaluated differently by a group of women and a group of men. As Hanne Haavind, she agrees that more women should participate and make decisions so that they are more in agreement with the society that research should serve. Women must take the responsibility themselves. As an explanation for the lack of women in these fields she emphasizes that traditional and biological demands are placed upon women which are incompatible with a total engagement in natural science research. Another aspect which Ruth Kleppe emphasizes is the extent to which there is discrimination in employing women for scientific positions. There have been studies in USA which do indicate this. She thinks that it is therefore important to have women on employment committees in all fields. To a certain extent women should also be given privileges in the form of time to do research and possibilities for contact with the international scientific community. Among other measures, this could occur by giving them extra research terms and promotion on the basis of competence. The universities and the Ministry of Cultural and Scientific Affairs have decisive responsibilities in such matters. She thinks that it is totally irrelevant to speak about the special problems of women in the natural science research environment in the same way as women researchers speak of their experiences. The same applies, she says, to setting up a feminist perspective for natural science research.

Conclusion

A few reflections about the future: We started this paper by presenting some numbers which showed the percentage of women in permanent research positions at Norwegian universities and colleges. Those figures were for 1983. Of course we do not have the figures for 1987 but we have recently received them for 1985 and these show a welcome increase in the percentage of women recruits. In 1977 women constituted 15 % of the recruits in the natural sciences, in 1983 19 %, and in 1985, 23 %. In technology, unfortunately, the percentage has stagnated from 1983 to 1985 and lies around 9 %.

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In 1977 it was 2-4 %. Considering permanent employment, change has not occurred. In 1983 it was 7 % which was the same in 1985 in the natural sciences, while for both years the figure was 1 % in technology. Achieving equal status is laborious. We choose to interpret the small progress we see within recruitment as a positive sign and that the Secretariat for Women and Research, among others, has contributed to this having happened. Work will continue and with full support from political leaders, from our own research council and we hope from the scientific community itself.

The Challenge of New Technologies: Computer Literacy -An Integrated Project for Women By Women -

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The introduction of new technologies has a key function in current and future social and economic development, in industrialized as well as developing countries. New information and communication technologies bring about a basic change in the structure of societies, social relations and jobs. Women's jobs in particular are more and more affected by these changes. The office and service sector, for example, has been radically changed by the new technologies: in the Federal Republic of Germany, 65 % of all gainfully employed women work in these branches.

The use, f.e. of word processors and calculating software coupled with the introduction of personal computers for special subjects leads to loss of jobs as well as to restructuring and reorganizing jobs. One of the widespread results is a change in the relevant qualification profile.

Along with the disappearance of what used to be typical women's jobs new jobs are being created for which the displaced women are usually not qualified. For years, unemployment figures have shown the disproportionately high number of unemployed women. During the years 1980 - 1982, in the Federal Republic of Germany the astonishing fact was observed that the number of women in office jobs decreased whereas that of men in the same sector increased. It therefore becomes evident that the saying "The more technical the office, the fewer women will

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work there" has already become a fact. This means that a typical and large domain of women's jobs is being lost without compensatory fields coming into sight.

Only those employees who are ready to start a new - often technical - education and training seem to profit from new vocational chances and job opportunities. Furthermore, besides thorough basic knowledge, they often need to have a solid and stable motivation to learn and favorable learning conditions.

Women's participation in further education and training programmes has increased somewhat in the past years, but it is still much lower that that of men. Particularly in the technical and computer-oriented training programmes, the number of female participants is considerably lower. In colleges, for example, for every ten boys in a computer science class there is only one girl.

The reasons for this behaviour are manifold. Women may take part in such programmes less often because in their jobs they are less frequently motivated to participate or, because of family reasons, they are not able to spend extra time on courses. Furthermore, many programmes have been conceived by and for male employees and their interests , at times suitable for them; very few programmes take into consideration women's needs, interests, their living conditions and their learning biography.

Roughly, two groups of determining factors can be distinguished:

- those factors women themselves are responsible for, and
- those inherent in the structure, content and methods of adult education programmes.

In addition, the labour market works as a decisive stimulating

or demotivating factor for women's involvement in further education programmes.
The often mentioned reserve women show towards technical matters also has serious implications with regard to the changing job structures. It seems to be the crucial factor from which further education projects - especially for women - have to start.
The complexity of reasons hindering girls and women from making use of offers available cannot be dealt with in this paper. However, discussions about these facts acted as a starting point for the development and conception of special training programmes for women. In 1984, a first women's computer project was started in Berlin, entitled "No fear of computers". The course is designed to help women with a commercial training background to become reintegrated into the labour market after having been away from it for family reasons.

In 1985 in Hamburg we initiated the project "Computer courses for women by women", which was the first step in the development of a comprehensive learning experiment for women.
Since then, nationwide feminist groups have been trying to start similar projects. In what follows, only the Hamburg project will be described.

The Hamburg computer training project is based on an integrated learning model, taking into consideration the comprehensive way most women think and learn. It is not intended to teach women how to push the right button but rather to enable them - in a self-confident and, at the same time, critical manner - to use computers. This means, besides being able to make intelligent use of the computer as a tool, also grasping some of the overall socio-economic and political implications of new technologies.

The general aim of the project is to increase women's technical and social competence, to encourage them to get involved in fields of public interest and to support self-determined and independent learning processes.

Besides teaching vocational knowledge, in special courses the philosophical aspects, for example, how thinking, creativity andlanguage in general are being influenced by new technologies, are being discussed.

The inclusion of social, economic and technical aspects of new technologies into the curriculum seems to be a successful way of making women interested in technical fields. The knowledge they obtain during the courses has three main strands:

- application : What kind of application programmes do exist, for example in office work? How can these programmes help to solve problems? How do I use these programmes?
- problems : What do I do to solve a problem, which steps do I have to take in order to achieve the desired result? Problem solving and algorithmic thinking is exemplified, it is the thinking process which is important, not so much the final solution.
- action : By encouraging awareness of the changes in the living and working environment and by critical interaction with problems, the women learn to think actively about solutions and their own willingness to become involved in actual developments.

The theoretical approach described is combined with adult oriented learning methods and a favourable learning atmosphere in the group. Although the women teacher proposes the context of each learning unit, it is the decision of the group how to structure the units and where to stress points.

Since the start of the courses, there has been an increasing demand from a great variety of women to take part: different age groups between 20 and 65 years, different educational and training background, employed and unemployed women as well as students, housewives and retired women. The interest of the women confirms our feeling that both the concept and the curriculum fit in well with women's needs.

The project comprises different courses. The introductory courses (with 40 learning units) gives basic insight into computer science and deals with fundamental social and economical consequences. After the completion of the basic course, more specialised courses (word/data processing, calculating, etc.) can be taken. Each course comprises theoretical and practical work. The personal experiences of the participants during the courses are exchanged and problems such as changes in communication patterns, physical consequences of computer work, are discussed.

The women can take as many courses as they want; they also can stop after one course and take up another course sometime later. Individual training time is offered outside of the courses. (During this time, children are taken care of)

In order to be able to expand our project and to build up a training network, the initial project team has founded a new women's training society, called :Institute for Future-

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oriented Education and Training for Women (IZBF). The IZBF aims at developing training courses by and for women corresponding to the demands of the labour market and enabling women to participate more effectively in social developments. Within the framework of the Institute, we also plan to evaluate our projects and to do research into women's situation and chances in the labour market.

In addition, the project team is preparing to build up an information and computer counselling center for women in Hamburg. This center will be based on the theoretical background described above. Courses will be offered to different women target groups, taking into special account the interest of young girls as well as of women who usually are not attracted by adult education measures. Special courses are actually being developed for girls in order to attract their interest for technical subjects at an early age as well as to show them the vocational opportunities in commercial and technical branches.

Finally, our interdisciplinary project team will be doing research into the question of whether women handle computer technology in a different way to men.

COMETS: Evolution of a National Women in Science Program

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That women are underrepresented in science is no secret to GASAT; indeed, a purpose of this international meeting is to address the problem of encouraging more girls and women in science studies and science careers. At the University of Kansas we developed COMETS (Career Oriented Modules to Explore Topics in Science) for use in grades 5-9 to (1) show all students -- BOTH girls and boys -- that science is usefully applied in all jobs, not just in research, medicine, engineering, and the like, and (2) especially encourage girls to study science and consider science-related careers. COMETS' development was supported by the National Science Foundation, an agency of the national government, and its dissemination has been supported in large measure by the TRW Foundation, a private, nonprofit foundation. COMETS now is published by the National Science Teachers Assn., a nonprofit teachers group.

The purposes of this paper are twofold. First, the COMETS curriculum materials and their use in the classroom will be described. Second, the evolution of COMETS from conception in 1979 to the present will be described as a starting point for discussion of how people interested in sex equity and science might proceed in order to have a national impact.

The COMETS Curriculum: "Monkey see, monkey do" oversimplifies the concept of role modeling. Just because students are exposed to people similar in some important characteristics to themselves, students will not necessarily follow the role models' lead. Nonetheless, if students are not exposed to people like themselves in certain roles, then they surely will not head in those directions. Given that, people interested in encouraging women in science have proposed that female students must be systematically exposed to women in science; and COMETS was developed to facilitate that process.

The two volume COMETS curriculum package is designed to be used as a supplement to the already-adopted curriculum of a teacher or school. COMETS is intended to teach science while at the very same time allowing students to be exposed to women science career role models and to see that science is used in all kinds of careers in their very own community. To do this, COMETS uses three kinds of role models. The first, a "community resource person," is invited by the teacher to the classroom to help teach science, but at the same time show students how the science they are learning is useful to the resource person on the job. In effect, the resource person is providing an answer to the frequently-asked student query, "Why should I learn that?" Teachers are encouraged to liberally use women as role models and to use non-college-educated as well as college-educated resource people.

The second kind of role model, the "historical role model," is used to help dispel the students' notion that Marie Curie was the only woman who ever did anything of note in science. Our materials have extensive information about nearly 40 women who won the Nobel Prize or achieved other successes in science.

A third kind of role model, the "contemporary role model," is contained in 24 biographical sketches of younger women in science careers from basketball coach (use uses kinesiology in planning her team's workouts) to doctor and zoologist. We recognized that while it is imperative that students know that Nobel Laureates include Rosalyn Yalow, Barbara McClintock, and Maria Goeppert Mayer, to name just three "historical role models," young women would have difficulty identifying with those outstanding women, who generally are much older than the students.

A science teacher using COMETS first turns to COMETS Science, a 460 page notebook, which describes over 100 teaching activities related to many physical, earth, and life science topics taught in grades five to nine AND to the cross section of science careers pursued in the community. When the teacher, for example, is preparing to teach about crystals, minerals, physical properties of matter, or similar topics, the teacher scans the COMETS Science activities which are keyed to science topics and potential resource people. In this case the teacher would be referred to a lesson called "Caramel" in which students discover the effect of temperature during production on the final crystalline structure of candy. Using suggestions found in COMETS Science, the teacher would contact a chemist, metallurgist, geologist, or related career person to come to the class in connection with this lesson. However, since community resource people ought not to be limited to university trained people, a welder or sculptor could talk with students about the effect of temperature on materials.

Prior to the career person's visit the teacher would introduce the science topic to the degree mutually agreed upon by the teacher and resource person; and the students, under the teacher's directions, would prepare questions about the person's career (e.g., What do you do? What is a typical day like? How does one prepare for your career?). Then when the career person comes to the class, the visit is begun with the captivating "Caramel" activity and followed by the career person telling the students how concepts developed in the activity are used on the job. Note that the students will have not only learned about an application of what they are studying but also seen that science is usefully applied right in their own home town. Following the activity and discussion of the applications on the job, the resource person can finish by answering students' questions about the person's career.

In connection with the resource person's visit, students read about or hear from their teachers about women in science. Articles and so forth on men abound, but a unique COMETS resource is information about historical contributions to science by women. Along with this "Caramel" lesson on crystals, the students can be told about the Nobel Prize winning work of Dorothy Crowfoot Hodgkin who used x-ray defraction data to figure out the crystalline structure of materials. Using the same technique, Rosalind Franklin contributed key x-ray defraction data about the DNA molecule which led Crick and Watson to postulate their famous double helix model of DNA.

A second resource, COMETS Profiles, contains 24 biographical sketches of younger women in science. In connection with this candy crystal lesson, for example, students could read about a geologist, Cynthia Dusel-Bacon, and her heroic struggle with a surprised bear while on field work in Alaska. Alternatively, they can read about Gisela Dreschhoff, who annually studies radioactive rock in the Antarctica, or Marylee Southard, a chemical engineer.

COMETS Evolution: In 1979 I was convinced that science teachers felt career education and sex equity were important in the abstract but that these teachers felt their first obligation was to "teach science." A second fundamental belief undergirding COMETS was the importance of role modeling for the encouragement of young girls in science and exposure to these role models early enough so that students still had time to enroll in high school in basic science and math necessary for further science study. The science classroom, which most early adolescent students attend 180 days per year, was thought to be the ideal arena where students could be exposed to role models; but there was a problem. How could teachers, steeped in the notion of "teaching science" as bones, rocks, and atoms, be pursuaded to involve role models in their teaching?

Our solution was to structure COMETS in such a manner that teachers would view its lessons as helping them do their first job, i.e., "teach science," while allowing them to attend to careers and equity, which they thought was okay, if it did not detract from what was "important." Even the program's name, COMETS, was chosen to highlight the importance of science without potentially scaring off teachers who might be offended by a program with a seemingly "women first" emphasis. The chapters in COMETS Science are organized around science subjects, rather than around women or careers. The lesson directions emphasize how the community resource person's visit will reinforce the science being taught.

Once having wormed its way into the teachers' hands and, hopefully, into the classroom, COMETS liberally and continually contains information and strategies whereby teachers can expose students to the three types of women role models outlined earlier. The teacher is exhorted to include women among the community resource people. Each of the 24 COMETS Science chapters includes information about historical women role models. Each chapter makes reference to how contemporary women role models can be used when teaching science; and each profile has language arts activities so that they can be used in teaching language arts as well as science...

We worked very hard to make (1) COMETS acceptable to the mainstream of science teachers and (2) procedures and materials easily available to teachers to encourage their female students in science. Of course, as was found out as a result of the major science curriculum development efforts of the 1960's and 1970's, no materials are "teacher proof" (and we would not wish materials to be "teacher proof"). Teachers can use the science lessons from COMETS and completely ignore all of the strategies and information on women in science. Nevertheless, I would argue that COMETS has a good chance of getting onto the teachers' desks; and teachers of good faith will attempt to use that resource to encourage their female students.

When the development of COMETS was completed, our next task was to get it to teachers. At that point we essentially were beyond the territory of the National Science Foundation which had funded COMETS' development, for they are loath to get involved in dissemination, seemingly in competition with private enterprise. Moreover, when COMETS was ready to be disseminated in 1982, a conservative government in Washington saw no federal role in education; we -- and our colleagues with other NSF-funded projects -- were encouraged to go to private enterprise.

And that is what we did in two ways. First, the National Science Teachers Association, a nonprofit, nongovernmental association, was asked to publish the materials. In this regard COMETS' attention to teaching science concepts while attending to careers and equity appealed very well to the notions of NSTA as a group and its leadership, many of whom had been kept informed about and involved in COMETS' development from 1979 on. Second, since NSTA was not in a financial position to pay for the initial printing of COMETS, although it was quite willing to lend its name and publication resources to the project, a private source of capital had to be sought. This task proved time-consuming and difficult. I first turned to professional science associations; and at one point a national engineering association was committed to providing printing costs, through their own fund raising paths, so that they could co-publish COMETS with NSTA. However, because of some problems within that association, they had to withdraw from the project in late 1983. I then turned to private foundations; and finally in late spring 1984 the TRW Foundation granted us funds to print COMETS. Starting in December 1984, NSTA has sold COMETS at cost; and the funds from sales are plowed back into reprinting.

With COMETS in print and being advertised by a respected national association with good entré to our primary audience, science teachers, our attention turned to educating teachers about COMETS. In that regard I have conducted workshops in nearly two dozen states under the auspices of science coordinators, career specialists, and people working in sex equity. As a corporation, separate from but associated with the TRW Foundation, TRW, Inc. has sponsored workshops in some of the communities where they are located.

Regardless of the effectiveness of those workshops, COMETS needed some way to enlist many more disseminators, for there are over 16,000 school districts in the country. Again, the TRW Foundation provided funds to support this new effort. With that help, in spring 1986 we published a *COMETS Workshop Leader's Guide*, a 100 page book of "script" for conducting workshops and originals for making transparencies and handouts for use in the workshops. Some 1500 complimentary copies of the guide were distributed to state science supervisors, science educators, career educators, and equity specialists, in cooperation with several education professional groups, like CESI (Council for Elementary Science International). We then turned our attention, again with TRW Foundation funding, to the production of a COMETS Workshop Leader's Videotape, which describes COMETS, shows it being used in a classroom (with Lynette Woodard, captain of the 1984 USA Olympics women's basketball team and current member of the Harlem Globetrotters, as the "community resource person"), and suggests strategies for conducting COMETS workshops. One or two complimentary copies of the tape were placed in spring 1987 in each state, usually with the state science supervisor or someone active in career or sex equity education. The state people responsible for the tape are circulating the tape via their "networks" through their states; and at each point the tape can be freely copied in its entirety.

COMETS workshops have taken numerous forms from very brief awareness sessions to a two week university course conducted at Clarion University in Pennsylvania. One particularly noteworthy training project, which won an NSTA STAR award, was developed at Indiana University - Purdue University at Indianapolis under the leadership of Dr. Terri Jump and funded by the Women's Educational Equity Act Program (WEEAP). The Project TEAMS for the middle school/junior high brought to each training activity multiple groups of seven people each: a science teacher, math teacher, counselor, building level administrator, central district administrator, parent and student. They received one day's training in teaching techniques to more equitably encourage girls in science; and then as "homework" they observed each other to ensure their use of these new techniques. Then they had a one day COMETS workshop followed by "homework" of using it in their classrooms. Next the same pattern was followed with EQUALS. Finally, two separate one day sessions were held to report back on the COMETS and EQUALS homework. Given the success of TEAMS in the Indianapolis area, TEAMS has been refunded by WEEAP to generalize the model to all of Indiana.

While working on dissemination, we also turned our attention from formative to summative evaluation with a national study using COMETS in eight sites from Albuquerque to Cleveland in grades five to eight. At each site the same teacher instructed an experimental and a control group. The experimental group received the COMETS treatment, using various role models as outlined previously. With the exception of COMETS, both groups received the same science instruction. Prior to and immediately following instruction students were tested regarding their attitude toward women in science and toward scientists. Data from these two dependent variables were separately evaluated by analysis of covariance based on a 2x2 factorial design with sex and treatment as the independent variables. Data from the eight sites were collapsed into one group for analysis. Pretest scores for the respective dependent variables were used as covariables.

The analysis of the data on attitude toward women in science showed that both main effects, sex and treatment, but not their interaction, were significant. Students in the COMETS experimental group ($n=133$; $\bar{x}=133.1$; s.d.=23.4) were found after instruction to have a significantly more positive attitude ($p<.05$) toward women in science than the control group ($n=153$; $\bar{x}=129.7$; s.d.=22.9). Not surprisingly, the attitude of women ($n=156$; $\bar{x}=140.5$; s.d.=18.2) was significantly more positive ($p<.01$) than that of men ($n=130$; $\bar{x}=120.2$; s.d.=23.8).

Regarding attitude toward scientists, the treatment main effect, but not sex or the interaction, was significant. Following instruction, the COMETS experimental group ($n=133$; $\bar{x}=120.1$; s.d.=13.1) had a significantly more positive attitude ($p<.01$) than the control group ($n=153$; $\bar{x}=116.9$; s.d.=13.4).

We concluded that, given these results PLUS the results of other studies (see Smith and Erb, 1986, for the complete results and citations), teachers of early adolescents can expect that if they use community, historical, and contemporary role models in connection with science instruction, then they can expect to have a positive effect on the attitude of *both* girls and boys toward scientists and toward women in science. (We were particularly heartened by the results with boys, for (1) in the early stages of COMETS we had been cautioned that "boys will be turned off by emphasizing women role models" and (2) boys as peers, friends, and [in the future] parents of girl students affect the girls' course and career selections.)

Conclusion: During this GASAT meeting, as we consider approaches to solving problems of access to science about which we all feel quite strongly, the present paper has been presented to stimulate our thinking about how to have a purvasive effect across our countries. Our approach in COMETS has been to provide "relevant" materials for teachers (i.e., materials that "teach science" as a first priority) just as we attempt to provide relevant instruction for students. The danger in our approach is that teachers can completely sidestep the equity aspects of COMETS; they can ignore using role models or exclusively bring men into the classroom and they can disregard the information about historical women in science and contemporary role models. However, this is always a danger; we accept that. Our position is that unless curriculum materials are gotten into teachers' hands -- and that is what we are working on -- then the very best equity materials are of no advantage to our intended audience, young women. Stated in another way, "you can lead a horse to water but you can't make it drink" is true; but also true is "a horse can't drink unless there's water." We are trying to make sure sustenance in the form of role models *is* in the hands of teachers to, in turn, present to women students.

References:

Smith, W.S. and Erb, T.O. "Effect of Women Science Career Role Models on Early Adolescents' Attitude Toward Scientists and Women in Science." *Journal of Research in Science Teaching*, 1986, *23*(8), 667-676.

COMETS Science and *COMETS Profiles* are available as a set ($24) or separately ($12.50) from the National Science Teachers Assn., Special Publications Dept., 1742 Connecticut Ave., NW, Washington, DC 20009. Handling and postage costs are added; prices are quoted in U.S. dollars in effect in 1987.

Differences in girls' and boys' attitude toward science - the result of a study among thirteen-year-old pupils in Hvidovre/Denmark.

Helene Sørensen

Chemical Institut, The Royal Danish School of Educational Studies

Summary

The paper will include an empirical study carried out among seventh-class pupils in the Danish primary school and a teaching program with respect to results of the study. In the seventh' class the thirteen-year-old children are for the first time confronted with the training and education in physics and chemistry.
One of the purposes of my study has been to learn something about sex-linked differences between girls' and boys' interests and attitudes toward physical and chemical science.
Based on the study I think that the teaching in physics and chemistry should be introduced at an earlier stage so that the girls can enter their puberty with an unprejudiced mind. One of the advantages would be that via their play in school the girls will be able to gain the experience that might not be possible in their time off.
In this year in school (1986/87) I am involved in a project with a third class (ten-year-olds) where I will strive to create a coherence between on one side the subjects physics and chemistry and on the other the pupils' everyday lives - both boys and girls.

Background

In Denmark pupils are confronted with their education in physics and chemistry when they are 13.
The Danish school system has a primary school, which starts when the children are 6 or 7. The pupils continue their education in the primary school till they are 16 or 17, i.e. 9 years' compulsory school education.
The socalled "kindergarten" class (in excess of the 9 years of compulsory school), which has only three lessons per day and which is the pupils' first class, is not compulsory but attended by almost every child.
It is possible for the pupils to leave school after their ninth class, when they can either start a further education at grammar school or choose to start an apprenticeship. They also stay an extra year in the primary school.

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From the 7th till the 9th class, the subjects "physics/chemistry" are compulsory with two lessons per week. The subject may also be continued in the 10th class.

At their 7th year at school, many girls expect themselves to do very bad in these subjects.
Results from several countries show that on an average boys achieve higher marks in physics/chemistry than girls do.
By the time they start the subject, most girls already "know" that it is an unwoman one. They are brought up to be feminine and their surroundings - parents, teachers, playmates, literature - have told them that girls are more verbal, less independent, more interested in individuals - and less interested in physics/chemistry, more modest in their wishes for their future education and less experienced in science-related activities than boys.

The Study

I have carried out a study to show some sex-related differences between the interests and attitudes of girls and boys, which may influence their future achievements within physical and chemical science, as mentioned in the paper to the Third GASAT-Conference.
The study has been carried out among 531 7th-class pupils in Hvidovre, a southern Copenhagen suburb.

Questions about Pupils' Interests

In the questionnaire I have included a number of subjects which may be part of the physics/chemistry teaching. The pupils were asked to indicate whether they found it important or exciting to learn about the matter in question.
It appears that the pupils have distinguished between "exciting" and "important", well over half of the girls found it exciting to learn about the rainbow, for instance. Few of them, however, have considered it important to learn about.
Few (8 or 9) fo the subjects, a majority of the girls has found exciting or important such as natural phenomena, additives to food, and pollution. Table 1 and 2.

Most of the 7th-classed had learned about/worked with electricity in class during some time before the investigation was carried out, and many of the pupils indicate that electric current and electricity as such are important subjects at home, but apparently it is not very exciting.

Experience within Physical and Chemical Science

In a number of cases, the pupils were asked to indicate how often they had been doing this or that.
Only few activities have been done by both girls and boys - such as tape recording, usage of calculator, photographing. Girls are experienced in domestic activities, boys in the activities that are often included in the traditional physics lessons. In general, girls are not as experienced as boys in the various activites, and only a few "girls"' activities - which - according to the boys' answers - have never been tried by boys. Boys generally "try" more than girls.

Consequently, boys are much more experienced in technical fields, thus being better able to relate the theories of the physics teaching to their own experience.
The pupils' opinions about what are girls' activities and what are boys' activities are surprisingly conservative (table 3). However, it is very well in line with that girls and boys actually indicate as their everyday activities. I would like to point out, however, that although the computer is not indicated by the girls to be a pronunced "boys' acitivity", this is not in line with the fact that far more boys than girls have been using it regularly.

Questions about Attitudes

I have also asked the pupils about their expectations to their future success in physics/chemistry.
I found that girls had a low degree of self-esteem, expecting to find the subject of physics/chemistry difficult (Fig. 1).

The girls proved to be less interested in physics/chemistry than the boys (Fig. 2).

Figure 1.: How do you think you will do in physics/chemistry?

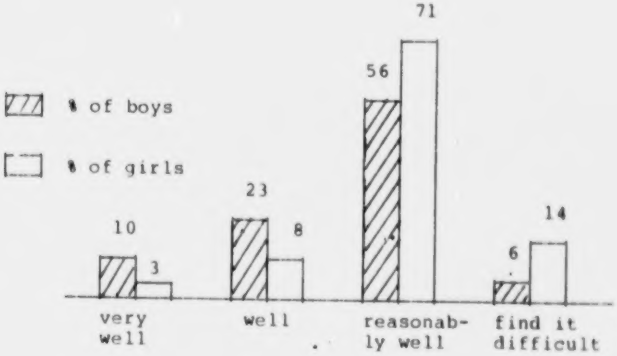
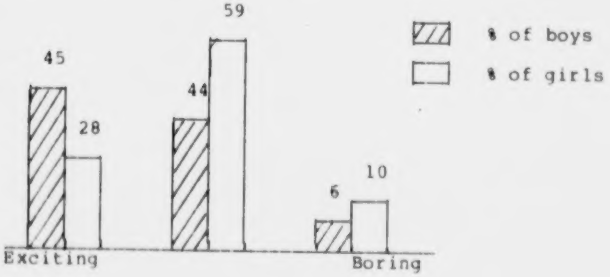


Figure 2.: Physics/chemistry is:



Two questions are related to their work done in the physics/chemistry lessons:

One is about how they would prefer to organize their work, i.e. self-studies, pupils' experiments, teachers' demonstrations, teachers' information, group experiments.

The other is about what would be the optimal learning situation for themselves.

Girls' and boys' answers differ only slightly. The girls have a slightly higher preference to group work than boys, and a small majority of boys give first priority to own experiments.

Conclusions and actions

It is possible to draw some conclusions from my data and from the results already found in corresponding British and Norwegian studies.

One conclusion is that it will be necessary to change the way and the contents of teaching in order to create a coherence between on one side the physical and chemical subjects, and on the other side the pupils' everyday-lives. In Denmark, the Minister of Education has set up committees to change the curriculum of the physics edutation in the "gymnasium" (high school) and the physics/chemistry teaching in the compulsory school system. In both committees, two of the members are women (the author of this paper is a member of both committees). At this moment it seems that our intentions will be followed in both committees.

Another conclusion is that the teaching in physics/chemistry ought to start earlier than in the 7th class. In connection with a test work, which I carried out last year with physics/chemistry teaching in a 4th and a 5th class, it turned out that even if both girls and boys were interested and absorbed in the tests, a questionnaire showed that the pupils meant that to study to become engineers or technicians did not appeal to the girls. Consequently, I have started some test work with a 3rd class with support from the Ministry of Education. It is the intention that the class is going to study subjects related to physics/chemistry until they as usual start the education in these subjects in the 7th class. This test work may enable me to follow, whether a change of the pupils' attitude to the subject will happen.

During this school year, the pupils have e.g. worked with dissolution trials, with chromatography, and with tests with air as part of a biological subject. The girls of 3rd class do participate as eagerly in the trials and are as interested as the boys. Both boys and girls have on their own started to make experiments at home.

However, a difference has turned out in the work of the boys and girls. The girls do pay very much attention to the fact whether all group members are allowed to make parts of the decisions and to touch the instruments.
It will be exciting to see whether the difference in the socialization of girls and boys will become of importance, when these pupils grow older.

The purpose of the present trial is to influence pupils and parents over a longer period of time in order to see afterwards, whether we can change the generally traditional attitudes held by our pupils.

Table 1.

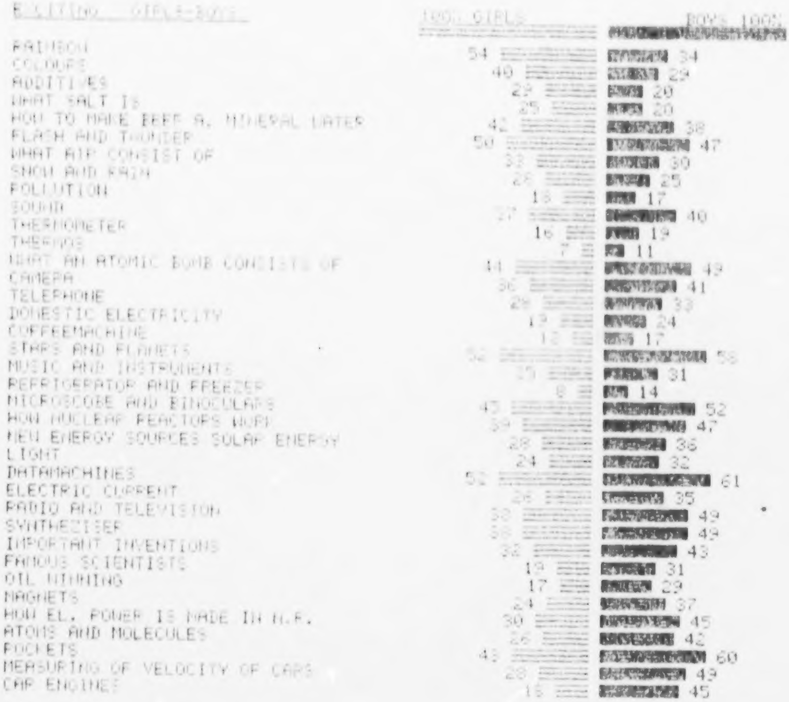


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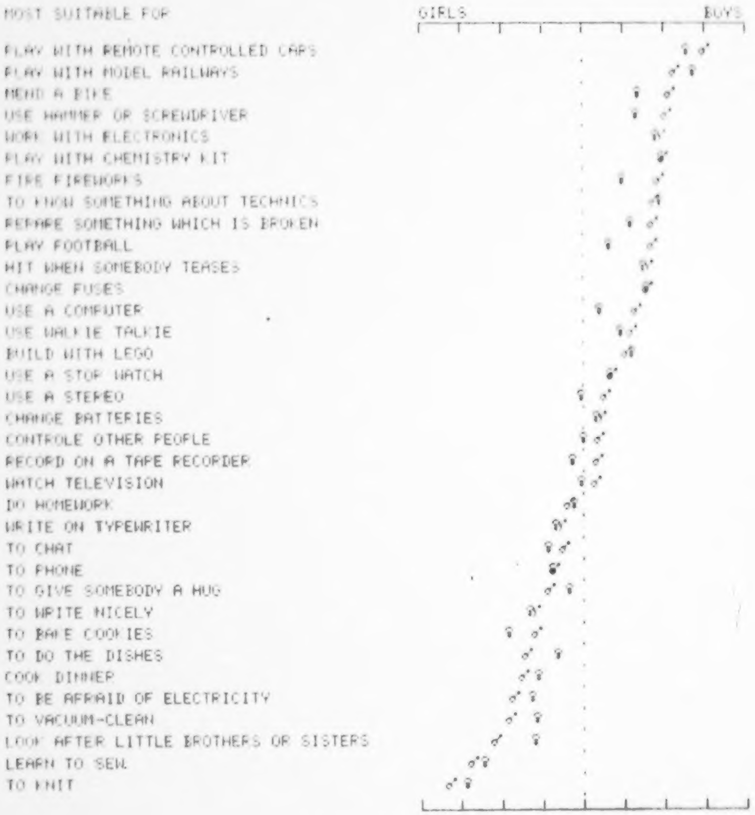
Table 2

IMPORTANT GIRLS-BOYS	100% GIRLS	BOYS 100%
ADDITIVES	64	52
POLLUTION	50	46
HOW TO MAKE BEER A. MINERAL WATER	20	17
DOMESTIC ELECTRICITY	61	52
HOW NUCLEAR REACTORS WORK	51	49
FLASH AND THUNDER	29	27
WHAT AN ATOMIC BOMB CONSISTS OF	53	57
SNOW AND RAIN	16	15
RAINBOW	7	7
REFRIGERATOR AND FREEZER	32	33
COFFEEMACHINE	17	18
OIL WINNING	28	30
WHAT SALT IS	18	20
THERMOS	6	9
LIGHT	44	47
THERMOMETER	17	20
MUSIC AND INSTRUMENTS	11	14
SYNTHESISER	8	11
WHAT AIR CONSIST OF	36	40
ROCKETS	27	31
ATOMS AND MOLECULES	41	46
STARS AND PLANETS	26	31
HOW EL. POWER IS MADE IN H.P.	34	40
SOUND	28	34
COLOURS	13	19
DATAMACHINES	60	68
CAMERA	16	24
MAGNETS	10	18
RADIO AND TELEVISION	40	49
TELEPHONE	27	36
FAMOUS SCIENTISTS	6	15
IMPORTANT INVENTIONS	27	37
MEASURING OF VELOCITY OF CARS	14	24
MICROSCOBE AND BINOCULARS	14	26
ELECTRIC CURRENT	51	64
NEW ENERGY SOURCES SOLAR ENERGY	27	42
CAR ENGINES	15	37

Table 3



The figure shows the difference between those activities that girls and boys have indicated as´suitable for girls´and ´suitable for boys´

GIRLS AND SCIENCE AND TECHNOLOGY

VOLUME THREE

CONTRIBUTIONS TO THE FOURTH GASAT CONFERENCE

July 24-29, 1987
The University of Michigan, Ann Arbor, Michigan U.S.A

Edited by Jane Z. Daniels Jane B. Kahle

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THE FOURTH GASAT CONFERENCE
VOLUME THREE

University of Michigan
Ann Arbor, Michigan, U.S.A
July 24-29, 1987

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Publication sponsored by The National Science Foundation

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PREFACE

This book is Volume 3 of a three volume set of papers edited for the fourth international conference of Girls and Science and Technology-GASAT 4. The conference follows those held in Eindhoven, The Nethelerlands - 1981; Oslo, Norway - 1983; and London, England - 1985.

GASAT 4 will be held in Ann Arbor, Michigan at the University of Michigan on July 24-29, 1987. The submitted papers and conference proceedings will increase international knowledge and understanding of the value and diversity of the contributions of girls and women to science and technology and of the issues. that affect such contributions. Special outcomes will include a better understanding of:

-barriers to women's education and participation in scientific and technological fields.

-strategies and interventions that can and do help to change or surmount those barriers.

-resources of people and materials, available around the world to assist and reinforce the work of Conference participants and their colleagues at home.

Participants in the GASAT 4 Conference represent 30 different countries. The papers written by these participants have been organized under the following headings:

-RESEARCH: Experimental
Qualitative
Empirical, Quantitative

-EVALUATION: Evaluation of Existing Situation and Recommendations
Evaluation of Specific Programs
Description/Case Studies
Theories and History

-INTERVENTION PROGRAMS

The papers within each areas are organized alphabetically by the first author's name. The three volumes of papers will be mailed to all particpants prior to the conference. Disscussion sessions will be held at the conference, focusing on each of the areas listed above. Following the conference, a book of conference proceedings and a congress book will be sent to everyone in attendance.

We hope that the research and experiences summarized in these three volumes expand your horizons and stimulate your thinking.

Jane Zimmer Daniels

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THE WORKING LIVES OF WOMEN ENGINEERS

Ruth Carter, Gill Kirkup

The Open University, UK

Abstract

This paper describes research into the working lives and personal histories of women professional engineers in the USA and the UK. The authors are only beginning the data analysis phase of their work. They describe the background to the research and raise some issues which are emerging from a preliminary analysis.

BACKGROUND TO THE RESEARCH

We have been involved over a number of years both with improving the situation of women technology students in our own institution and with contributing to a wider analysis of the relationship between women and technology. The ideas for the present research developed directly from our work. For example, we were increasingly concerned that there was an uncritical enthusiasm to encourage women to enter jobs and careers in science and technology without any discussion of the problems that women, especially those with family responsibilities, face in these jobs . We have elsewhere criticised the UK Women into Science and Engineering (WISE) intiative for having such an uncritical postion (Bruce and Kirkup 1985). Statements issued by the UK Equal Opportunites Commision argued that whatever historical causes had contributed to the present under-representation of women in engineering and science, they no longer applied and could be dismissed.

In our own institution we were having some success at recruiting more women to study courses in technology, but we felt that we were not able to give them the kind of career guidance they were looking for. The information they wanted was to do with which jobs could most easily be balanced with family commitments, especially childcare, and what suggested strategies exist for maintaining the balance. We were aware that very little research had been done on the lives of successful professional woman engineers, although work had been done on women in other professions (Marshall 1984) and on women working at different levels in the labour market (Coyle 1984, Walshok 1981). It seemed to us to be a promising area for research; it has indeed proved very fruitful.

RESEARCH DESIGN

We decided to concentrate on women who are professional engineers. In the early 1980s women formed just 2% of professional engineers in Britain and 3.5% in the USA. This is a small pool to investigate relative to the numbers of women working at any level in both countries, but a pool forming a crucial professional group.

We designed a schedule for an indepth interview to cover a variety of areas of the women's lives and histories. We chose an indepth interview rather than a survey because we believe that a qualitative methodology is more likely to give us access to the women's understandings of their experiences (for a discussion of the politics of research methods see Stanley and Wise 1983, Bowles and Klein 1983, Kirkup 1986) The interviews explore education and training, entry into work and subsequent career paths, career development and ambitions, professional activity, relationships at and outside the workplace, and the variety of tasks which constitutes particular engineering jobs. They also explore the strategies that women engineers adopt for coping with family and other non-work commitments and their sources of support or opposition amongst family, friends and colleagues. We are interested in the quality of life for women engineers, what their life histories have in common and how far success in professional life as an engineer is compatible with a satifying personal life.

We obtained volunteer interviewees through requests to the Women's Engineering Society UK (WES) and the US equivalent: the Society of Women Engineers (SWE) and to a large group of the professional engineering institutes as well as by word of mouth recommendation. During 1986 we interviewed face to face or over the telephone 37 women engineers in the UK and the USA. Interviews averaged an hour in length and were taped. Ruth Carter was spending a sabbatical year in Washington DC, and this gave us the opportunity to make our study cross cultural. We hoped that we might be able to identify some of the cultural variables which contribute towards the slightly larger proprtion of women engineers working in the USA.

Our sample ranges in age from early 20s to early 60s although the majority are in their 30s. Roughly three quarters are married, and half have children. Their areas of work cover almost all the US National Science Foundation categories of engineer, with civil, electrical and electronic having the highest representation.

PRELIMINARY FINDINGS

In the space available we have concentrated on only some areas covered by our interviews; in particular the present experiences of work and private life, and balancing the two. Because we have concentrated on problem areas, we do not deal with the nature of the satisfactions that the engineers experienced, and it is worth noticing that our sample expressed, overwhelmingly, satisfaction with their lives.

Time Pressures and Time Management

The demands of a professional job are heavy. Although feminists have done a lot of work into the difficulties experienced by women in poorly paid, low status jobs; and we do not want to underplay these difficulties, there has been little work done on the difficult demands of professional work. Almost all of our sample were in full-time work, and that meant almost infinitely elastic hours depending on the demands of a particular 'job' (or contract) at any time.

Women working for private companies where profits depend on completing jobs quickly, are under the most pressure with regard to the amount of control the company exercises over their hours. One of the UK women with very long hours is a senior project supervisor. She is in charge of testing designs and during the testing period she will work from 8.00am until 10.00pm including saturdays and sometimes sundays. She remarked that she tried not to do more than two consecutive weeks like that. When she is involved with another part of the cycle of the job, she can relax, and is back to working nominal hours of 8.00am till 4.30pm. However she has had up to nine projects in one year, which would necessitate nine such obligatory intensive periods of work. Other women have posts of senior responsibility, for example in public health work, which means that they may have to be 'on call' regularly over weekends. These kinds of pressures become extremely onerous when the same woman has the major responsibility for young children.

Most of the women with young children, and some of those without, tried to make a distinct separation between work and home. As far as possible they tried never to take work home, and 'avoid weekend work like the plague' as one commented. The other side of the same coin is that the women need to set up reliable childcare, because when they are at work they do not want to have to think about family responsibilities. One said:

> *'We have a super nanny who looks after the children. I think that's essential, it means that I can just go out of the house in the morning and not worry about what is going on at home. In fact it's been like that from the day I went back [after maternity leave].'*
> *(UK civil engineer)*

Women also have to make very good use of all their time at work. Very few used their lunch breaks to do family chores like shopping. They tended either to work through their lunch or they would give themselves an hours' relaxation, by reading a book, going to a gym, swimming or running, or in one case playing patience with a computer. They compensated for such tight organisation of their professional hours, by being more relaxed when they got home.

The strategies that the women in our sample adopted of such clear separation between home and work do not suggest that more demanding careers necessarily provide any more integration of these two areas, or break down the public/private split in ways that more radical feminists believe are necessary, or that fit some of the notions of new technology home working. However most women expressed great satisfaction with their careers in engineering despite the demands.

Part-time Work

Only one of the U.K. sample had adopted a strategy of part-time work after the birth of her first child. Professional engineering work places seem to be unable to cope with part-timers. She remarked:

> *'One thing I found working part-time was that other people in the office found it very difficult, I felt, to appreciate that I was not working the number of hours they were working. And they didn't seem to scale down that sort of element.' (UK civil engineer)*

The same engineer also saw the more obvious drawbacks to being a part-time worker:

> *'It does mean that you've got to perhaps take on jobs that you'd be a bit more resistant about. You've got to lower your standards. Well, not your standards, that's not the word, you've got to lower your pride a bit perhaps, obviously you can't take on the bigger jobs that you'd like to have, even though you're capable of doing it'*

Partners

The majority of the married women in the sample are married to engineers, some work in the same company as their wives although always in different departments. This may be of benefit because the partner understands the nature of the demands of the work. In describing a typical day most women described situations such as breakfast where partners prepared their own meal and sometimes even left the house before the women were ready. Although a basic division of labour existed within the house and was often quite traditional, this was explained as being the most efficient way of getting work done, but the tasks the family required of the woman were scaled down. There was certainly a sense that women did less housework when they were married, because it was now shared:

> *'When I was single I used to be very houseproud, do all the housework, generally looked after myself. Since I have been married I've become rather slacker. I think probably my work has got more demanding so I don't do the housework very often.' (UK metallurgist)*

However another woman identified a more subtle problem, that even if the tasks are shared the responsibility may not be:

> *".........I try to plan a menu in advance and do one local shopping trip during the week. My husband and I share that. But what I found was that when I sat down to plan a menu: say, John, what do you like?' Oh, I don't care.' And it all fell on my shoulders. Now he's trying to contribute more." (US electronics engineer)*

Children

Most of the women we interviewed with children had young children. This meant they relied on paid childcare to enable them to work. Childcare was equally likely to be done by a nanny who came to or lived in the house, or at a nursery or childminder. One woman had a partner who had given up his career to look after their child. Although childcare in individual homes has never been the major form of care supported by feminists who have argued for socialised childcare in nurseries, when women work long hours it is easy to see why a nanny is preferred:

> *'I get up at about twenty or quarter to seven, and get washed and dressed, have breakfast with my husband. If our eldest son is awake the he may come down and have breakfast with us. We have a live-in nanny and she is technically on duty from the time we leave the house. It doesn't mean that she has to be up, so if our son isn't up she may not get up either. She knows that she has to get up and deal with him when he does wake. If he is up then we will give him to her as we leave. And we try to leave the house by about twenty to eight.' (UK civil engineer)*

Contrast that with the routine of someone using a private nursery:

> *'I aim to get up at seven, usually I oversleep.........my husband wakes me up. I try and get as ready as I can before I wake Sam up; that's the baby. He wakes up between seven and half past. Like me he takes a long time to wake up, so I quickly get myself dressed then give him breakfast. I don't eat breakfast myself. I get my husband's breakfast as well so we can eat together. I then dress the baby and I usually aim to leave the house about quarter past eight. I live only five minutes from the nursery, its a private nursery. A nursery in Btown. So I take him to the nursery, drop him off and then drive into work which again is only another five minutes at most'(UK gas engineer)*

The UK engineers with young children had all taken advantage of statutory maternity leave and returned to work. Their US counterparts had also returned, but as maternity leave provision varies considerably from State to State and from one firm to another, the amount of leave they had taken was almost always the result of personal negotiation with their employers. The older women with children in the sample tended to have taken a career break, out of choice at the time, but found that they needed retraining when they tried to re-enter the job market. One electronics engineer described the humiliation she experienced when, after having experimented with a low level part-time job and found she loved being back at work, she applied for jobs 'proper':

> *I got a couple of interviews, which when they were technical interviews it was a disaster, I was totally humiliated. I just didn't know what they were talking about, so I thought I'm not putting up with this. So I looked at the IEE news and saw an MSc advertised and wrote off to M- university and they said come and see us.'(UK electronics engineer)*

The Experience of Sexism in the Workplace

We use the broader word sexism rather than the more specific term discrimination, because most women when asked whether they had ever experienced any discrimination replied that they had not. When they were asked more generally whether they found being female was an advantage or a disadvantage to their work they usually had a number of anecdotes which described active sexism. In most cases they saw the incidents as being relatively minor issues and not worth getting annoyed about. However, it is likely that an accumulation of these incidents will have the effect of undermining confidence and authority.

In the office there was a common problem of visiting clients and people phoning, assuming that woman engineer was a secretary. The assumption is often implicit in the way the person speaks rather than explicitly stated. So the engineer feels that she has to deal with it implicitly by perhaps demonstrating by her grasp of the subject that she is technical staff. Jokes by male colleagues such as remarking to an engineer in a meeting that he thought she was only 'here to look pretty', add up to a feeling that the women are constantly countering an environment in which they are trivialised because they are women.

One engineer found it difficult to establish her authority with female secretaries and her comment expressed the tension between herself and them:

> *"I don't get along well with some secretaries because they are used to taking orders from men, and seeing men in my position. There's one especially in the office that resents my position tremendously, and I have told her that if you want what I have you have to work for it..........but she should know by now that what she needs to do is to go and take some college courses."(US highway engineer)*

Site work for those whose jobs entailed site visits were also a likely place to experience sexism. At the most basic level an engineer had to think about what she was wearing:

> *"I suppose if I'm in the office looking smart in skirt and high heels and I suddenly go on site then that's a problem, but it's fairly rare. When, when I'm sort of feeling organised I tend to keep a pair of jeans at the office for that anyway."(U.K. civil engineer)*

One engineer had an experience similar to being presumed to be the secretary in the office. When she went on site with a technician, the site foreman would invariably direct all his comments to the technician as if she was the junior.

Some engineers had in their past experienced site gangs who refused directly and indirectly to work with a woman. In these cases the women got senior management to deal with the problem, since they felt it was not their job to do so. The most overt sexism in the UK sample was reported as coming from unskilled and manual workers, and the engineers felt least threatened by this group of workers:

> *'When it's manual workers like that I just try to ignore it. I'm never I think going to change their attitudes. When I meet it among superiors then I think you have to confront it' (U.K. civil engineer)*

In the US, however, some engineers reported being shielded from the coarser aspects of the shopfloor by the male workers themselves:

> *'There's no swearing or dirty jokes......if they know me and I've worked with them before, theyr'e protective if someone is doing something that shouldn't be done to a lady, and I'll mention it too.' (US mechanical engineer)*

Women described how age gave them confidence, both to be 'womenly', and most of the engineers we spoke to believed that women should be 'womenly' and professional at the same time, and to be unruffled by sexism.

> *"Now if I'm on site and I'm climbing over a pit and there's a man there I will ask him to give me a hand, and I don't feel that its wrong to do this anymore. As a woman I'm quite happy to be a woman and if a man will give me a hand to go up a ladder or step over a ditch then I'll do it. I think that probably has something to do with age and confidence, or something. Whereas, I think probably when I was younger I wouldn't have done that, I would have rather fallen down the pit!'(UK gas engineer)*

Two other specific areas which UK engineers identified as being difficult for them as women , were working abroad, especially in the middle east, and social activities. The first was an issue that was dealt with by the company rather than by them as individuals. The company arranged their work so that a male engineer would make the foreign visit. For engineers with young children this was quite acceptable, rather less so for others. The second was something that women had to take on at an individual level. They had to find topics of conversation around the interests of their male colleagues, something else that got easier with age, and the aquisition of a morgage , property and children. US engineers were less likely to be involved in foreign travel but frequently reported awkward situations connected with their early business trips within the USA.

> *'Bill turned to me and he said: 'What's [your husband] think of you going on a business trip?' And I said: 'Well, he assumes I'm going to go, I told him we had two or three things coming up.' And he said; 'Well I'm uneasy with it.....I don't know what my wife will think'. And he himself was uneasy about the trip and we finished our business...........he turned to me and said:' You know, you're alright as a travelling partner'. 'But it was something he had to deal with.' (US nuclear engineer)*

Most of the women described what they experienced from male colleagues as 'banter' and 'badinage', without malicious intent. The engineers who were most successful in dismissing the sexism that was directed at them had a way of empathising with the problems they felt that their male colleagues had to deal with, in ways similar to the successful female blue collar workers described by Walshok:

> *'A lot of it isn't meant maliciously I don't know if its intentional because if you are the only woman they've had dealings with, or one of the few women they've had dealings with during their forty years of working life, it's going to be difficult not to treat you as a secretary, and not treat you as they would their wives and daughters' (U.K.gas engineer)*

A few of the engineers felt that there were advantages in being a woman, for example

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male colleagues were less competative towards them, and they found it easier to get information and ask for advice. However, it was not a universal experience and has to be seen in a context where women workers are perhaps not regarded as equal.

DISCUSSION

The engineering profession continues to play an important role in developing the technical infrastructure on which Western capitalism builds. Yet we know less about the experiences and behaviour of members of this profession than we do about shop floor factory workers and their lives. The problems of researching the powerful are well known. However, we have had a number of women members of this powerful profession enthusiastically helping in research which they hope will encourage more women to join them.

In this paper we have briefly touched on a few of the problem areas from the lives of our sample and the strategies they adopt for practical and psychic survival. We need to look further at the nature of their satisfactions, their support networks, and those important aspects of past experience that led to the present choice of career. We also need to relate the women's experiences to the economic and political context from which they speak. Such an analysis is important if we are interested not only in improving the situation for women, but also perhaps in creating alternative work and social structures.

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9

ACCESS TO SCIENCE RELATED CAREERS BY YOUNG SINGAPOREAN WOMEN

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Science Education & National Development

Having set their sights on economic development as long ago as the late fifties, developing Asian nations have focused their attention on the build-up of a scientific and technological infrastructure. Likewise, policy makers and technocrats in Singapore have regarded the build-up of an indigenous scientific and technological manpower as a means of procuring ecomomic growth and improved standards of living for all Singaporeans. With much less latitude for error in economic planning than her oil-rich neighbors, Singapore's manpower policy has been particularly vigorous in pursuit of a manpower base skilled in science and technology. In fact, Singapore's commitment to technological development was made explicit as early as 1959 when the fledgling Peoples Action Party spelled out their party manifesto:

> In our universities we should encourage the expansion of the teaching of science and technology. Should the universities wish to expand their science faculties and their engineering institutes, they will find the P.A.P. government attentive to their request for finance. Similarly, the Polytechnic will be encouraged to play its proper role in the training of technicians.
>
> It is not sufficient to produce top level engineers and technicians. It is necessary to improve the both the quality an the number of skilled workers. For this we should set up a network of vocational institutes both for full time and part time students, e.g. evening classes for workers, as well as to organize systematic apprenticeship training in industry...
>
> In a long term technological development programme special attention should be directed to the teaching of science in the schools so that these could feed the universities, the polytechnic and vocational schools with good material. (1)

The message was clear. The role of school-based science and technology education in a much-coveted 'technological revolution' was given full priority. So, during the sixties and early seventies, curriculum planners in Singapore were engaged in concerted efforts to improve science curricula. With varying degrees of success, innovative science curricula developed in the UK were adapted for use in Singapore and new curricula were developed locally. Simultaneously, special laboratory and workshop facilities were provided and some secondary schools were expressly designated as 'secondary-technical' schools.

Accordingly, growth and development in technical education at the post-secondary, technical and vocational levels mushroomed. Instead of falling under the administration of the Ministry of Education, however, this sector of the education system was brought under the governance of the Economic Development Board. The EDB sought assistance from foreign investors and, as a result, a number of specially equipped Government Training Centres and Vocational Institutes were built.

Throughout this initial period there was a conscious effort to popularize science and technology education in the schools and equal access to technical education was afforded to both sexes. (2) It was anticipated that, in the long run, about half of all girls would avail themselves of technical studies and enter the technical stream at the upper secondary level - thus broadening the base from which prospective technically skilled workers and technical expertise could be drawn.

The Impact of Singapore's Technological Revolution.

Let us look now at the manifestations as well as the impact of Singapore's technological revolution as it approaches its third decade of existence. Few would dispute that evidence of technological development is pervasive in Singapore. The soaring downtown skyscrapers, the well-equipped hospitals, the diversity of industries, not to mention Singapore's impressive GNP, speak for themselves.(3) But in spite of the anticipation that a technological revolution would bring about a better life for all, evidence now presents itself almost three decades later that the status quo is not entirely as it was intended to be. The abundance that technology has brought is distributed unevenly, mainly by virtue of who ends up doing what kind of job.

In retrospect, it might have been anticipated that a technological revolution occurring at such a rapid pace would reinforce already existing socioeconomic differences. On the other hand, divisions which were arguably less predictable (or at least left unspoken by manpower planning strategists) have taken effect - that is, along the lines of gender. To be more specific, the unskilled and semiskilled labor for the electronics, clothing and light industry technologies have been filled predominantly by female workers, while careers at the executive, managerial and professional levels have been monopolized by males. This is disconcerting considering that female participation in the workforce is high compared to neighboring Asian countries. (4)

Of the professional female workforce, few appear to be in the scientific and technical professions and women who do attempt to access technical occupations usually end up with lower salaries than equally qualified males.(5) This trend has been consistent in spite of a changing economic climate which increasingly favors a workforce with high technological and scientific skills. For example, since 1981, the Singapore government has invested 30 million dollars to encourage research and development in science and technology. This example has been followed by the private sector to the tune of $214 million invested in R & D in 1985/86.(6)

This massive injection of money into R & D activities has meant that science related careers at the professional level in medicine, chemical engineering, pharmaceuticals, biochemistry, robotics, aeronautics and so forth continue to expand and would ostensibly hold many prospects for qualified young women. It is therefore imperative that girls who are identified as talented in science as early as primary or secondary school should be encouraged to follow career paths that would enhance their opportunities to access the scientific and technological workforce in equal competition with their male counterparts. This is important not only to give women equivalent earning potential but also because women have a valuable contribution to make in ensuring that appropriate new technologies are relevant to womens' needs.

Early Influences

In addressing the problem of underrepresentation of young women in the fields of science and technology, it may be fruitful to look at the influences and constraints that may be acting on the development and career decisions of potential young female scientists.

From a developmental perspective, the root of the problem has inevitably been firmly implanted even before the child ever enters school. From the time a female child finds out that she belongs to the female sex, she begins to identify closely with stereotypes associated with females. Over time, girls are socialized to think that they should value things differently from boys and they begin to involve themselves in different types of activities. This tends to also include preferences for particular school subjects.

Later on, young women who are in the process of choosing possible career paths are also bombarded with the realities of the adult world in which many more men than women are represented in the fields of science and technology. Parental pressure, peer influence, lack of assertive teacher support and sheer convention of numbers may all add up to the fact that girls accept female stereotypes and do not consider all the possible alternatives open to them.

But that is not to say that these overwhelming enculturating influences are all enduring. There is a strong possibility that intervention which attempts to moderate these influences could take positive effect through positive role modelling by parents and teachers as well as through provision of experiences that enable children to reexamine female/male stereotypes.

A Chain Reaction

But, if we take the effect of these early enculturating influences and compound them with what happens in the school system itself, it is no wonder that a void will show up at tertiary institutions. For, there is a distinct link between the number of young women who enroll in pure and applied science faculties at tertiary institutions and the numbers admitted to science streams at the preuniversity level. Accordingly, the numbers of female science students enrolled at the preuniversity levels depend very much on how the students have been streamed lower down in the school system.(7)

At present it is not clear to what extent the streaming process that occurs in secondary schools is consistent across schools. It appears that streaming is left to the discretion of the school administration and depends almost exclusively on the student's examination results.(8) Student preferences are rarely taken into account; neither, it seems, are the requests of parents. This question of allocating students to the science and technical streams is one that must be addressed if the problem of 'science shy' girls is to be properly understood. For, in the Singapore system, once a student (male or female) has opted out of the sciences at the early age of fourteen years, the student is effectively excluded from taking up a science career at any level in the future. Because the streaming exercise is so highly deterministic it must surely be one of the primary influences on career decisions of girls in school.

Related to this point is the question of the elitist nature of science streams in Singapore secondary schools referred to by Tang (1984) (9). How elitism affects the choices made by and for girls in terms of their eventual placement into arts, science, commercial or technical streams is a question

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yet to be explored. The elitist nature of science streams may indeed motivate some girls to continue their science studies, but on the other hand, it may discourage many others. Girls in Singapore have consistently performed better at languages than boys (as indicated in national examination results). Continuing to study languages at a higher level may seem the obvious choice for some girls, even though they may also have potential talent in the sciences.

Moving up from secondary schools to look at science student enrollment at the post-secondary and tertiary levels, the picture is far from encouraging. The numbers of young women entering the applied science faculties of polytechnics and tertiary institutions is only a fraction of the number of males in the same faculties. This is glaringly evident in the applied science faculties of the National University of Singapore and Nanyang Technological Institute, the latter of which is Singapore's principal institution for preparing engineering graduates. (10) Yet, without a sufficient base of tertiary educated professionals, it will be impossible to incorporate more women into scientific and technological careers at the executive and managerial levels.

Preference or Policy?

The evidence presented so far begs the question: to what extent can womens' underrepresentation in science and technology related careers be attributed to self-selection (ie: young women opting out of science) and to what extent is it linked, directly or indirectly to streaming exercises and other policies taking effect in various levels of the education system? After all, the National University of Singapore's medical school has made no secret of its policy to limit the intake of female medical students to one third of the total enrollment. (11) Does a similar quota exist in the applied science faculties of the university?

Perhaps it is ominous to note here that at lower levels of the school system, ie. in the gifted children's program (which offers special curricula in math, science and computer studies) there appears to be an unannounced quota system in effect. The 1984 figures show that of the 100 children that began in the program at Primary 4, there were 72 boys and only 28 girls. At the secondary level, the split was 63 boys and 37 girls (Singapore Bulletin 1984). The recently published 1987 figures for intake to the gifted program showed a remarkably similar ratio of 110 boys and 65 girls.

Yet another example of differentiation between girls and boys at the school level should be discussed here. In January 1985 it was announced that technical studies would no longer be an option for girls at secondary 1 and 2. Instead, home economics would become a compulsory subject for all girls at that level. A further policy announced in January 1987 specified that all boys at secondary 1 and 2 would take technical studies, regardless of the career they might eventually pursue. Curiously enough, in spite of the number of boys who might be expected to end up in Singapore's hotel and catering industries, the option of taking home economics is now no longer open to boys.

Can it be inferred then that there is educational policy that effectively works to predetermine the career paths of male and female students and that such legislation, made public or not, limits the access of girls to science and technology careers? If so, will this not exacerbate rather than ameliorate the imbalance of female/male participation in such careers in the future - especially at the professional, executive and managerial levels? And, if this is the case, won't the scientific community in Singapore be the poorer for it? Ironically, enhancing young Singaporean womens' access to science and technology careers should be of utmost importance to any institution or governing body interested in harnessing the best of Singapore's talent to contribute to the continued advancement of technological progress of Singapore.

A Proposed Agenda for Action

In order to enhance the possibility of young Singaporean women to enter the 'pipeline' towards higher level science-related administrative and professional careers, much more information is needed on the extent to which the influences and constraints mentioned so far in this paper take effect and when. Only when research has been undertaken to carefully examine the range of issues presented can the most pertinent issues be identified.

Thus, a proposed agenda for action would call for a holistic investigation into girls' participation in the sciences at all levels and from all perspectives. Among the components of the research should be an investigation into the ways in which school science and other text materials project a gender bias. Attitudes of parents and teachers concerning girls entering science and technology careers should be surveyed to find out to what extent these factors influence girls' career decisions.

At the primary and secondary levels the performance of male and female students in school based examinations should be carefully monitored. From this data it should be possible to infer characteristics of teachers and schools that are conducive to the successful performance of girls in science. With this information at hand, an intervention strategy could be formulated and efforts to popularize science with a pilot group of schools could be evaluated.

Before streaming exercises occur at the upper secondary level, both boys and girls should be counselled so that the most capable and motivated students are encouraged to pursue science studies at higher levels. Long-term follow up studies on the success rate of the girls who have received help through the counselling program should be attempted.

At the preuniversity level, the attitudes and achievements of female students who have opted for science subjects should be surveyed. They should be solicited for their opinion on the propensity towards differential treatment by their lecturers. Existing and potential mechanisms for peer group support of women in science faculties should be explored. This research agenda for preuniversity centers should be duplicated at the tertiary institutions.

Finally, the problems of female students entering the job market should be identified. Perceptions of this group of individuals who have broken through the stereotypes lower down in the education system and who are now about to confront problems of stereotypes in the workplace can provide valuable insights which, in turn, should point the way to possible interventions.

Concluding Remarks

It has become part of established public rhetoric to espouse that Singapore's major and most valuable resource is its people. The argument presented here is that an essential part of this resource is under-challenged and under-utilized when capable young women who have an interest and aptitude in pursuing careers in science and technology fail to do so because of overwhelming deterring influences.

The influences and constraints acting on the participation of girls in school science and women in science and technology careers identified in this paper pertain to cultural, educational and social norms as well as to educational policy. These influences and contraints permeate the education system and mutually reinforce each other culminating in an inhibiting effect on the participation of women in science and technology. It has been argued that womens' participation in science and technology at the management and decision making level is important to ensure that new technologies are appropriate to womens' needs.

It has further been proposed that an affirmative attempt be made to address the problem through a comprehensive research agenda. Once the true extent of the problem and its causes and consequences have been identified,

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a comprehensive program can be made to popularize science and technology for women, enhance their access to science and technology careers, and thereby enable them to make an even greater contribution than they presently do to the continuing technological progress of Singapore.

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1. PAP party manifesto: The Tasks Ahead, The Peoples Action Party's Five Year Plan 1959-1964, Petir: Singapore (1959) pp 23-24.

2. Both girls and boys were allowed to choose between technical studies and home economic when they entered secondary school. This changed in 1986 when technical studies was made open only to boys.

3. Singapore's 1985 per capita GNP was cited as $14,344 in a publication by The Information Division, Ministry of Comunications and Information entitled: Singapore Facts and Pictures published in 1986.

4. Refer to Lai, A.H., Ng, S.M., Pang, K.F., & Wee, V., (1985) The Decade for Women in Singapore: An Alternative Country Report. Unpublished paper presented at the Asian Womens Conference to Assess he Impact of the UN Decade for Women, Davao City, Philippines.

5. Graduate Employment Survey 1985 (1986). ARC Project No 55016/10 Prepared for the National University of Singapore

6. Refer to a publication by Singapore Science Council: Singapore Science and Technology, June 1986, Page 3.

7. At the secondary 3 (equivalent to Grade 9) students are streamed into science, technical commercial and arts streams.

8. Personal communication with a Secondary School principal who wishes not to be named.

9. Tang Ning, N. (1984). Investment and Overinvestment in Science Education. An unpublished paper presented at the International Review Meeting on Education Science Policy Research and Action, International Development Research Centre, New Dehli, India.

10. Refer to the University Bulletin 1986, National University of Singapore, pp. 34-42 which gives comparative data on male/female student enrollment in various faculties.

11. Reported in the Forum Section of The Straits Times Sept 9th 1984

18

Teachers & Students: Gender Differences in Science Classrooms

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> Interviewer: Is there something in them [boys], that it is beneath them to like biology?
>
> Teacher: Well, that's part of the macho thing - that real students go on and do physics and chemistry and that's the way it's been ever since I can remember - ever since I went to high school. Now, a lot of that is being broken down, but it's very gradual. I mean, the thing is that girls, for example, didn't go into physics and chemistry. I mean, to a large extent that is still par for the course. I think underlying it is that a lot of girls don't have the confidence, and they don't feel they can do it [chemistry and physics].
>
> -(Year 10 Science Teacher, Western Australia, September 9, 1986).

Introduction

Recently, gender research has shifted its focus from the study of girls and women as separate and distinct entities in classes and schools to the interaction patterns which integrate students and teachers into a productive unit. Earlier work has identified interaction patterns which are detrimental to girls and women (Hall, 1982), and ones which promote the achievement and retention of girls in science (Kahle, 1985; Whyte, 1986). Galton (1981), for example, describes three teaching styles in science:

Problem Solver, which involves a high frequency of teacher questions and a low frequency of pupil-initiated or maintained activities;

Informer, which uses teacher delivery of facts and an infrequent use of questions except to recall facts; and

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Enquirer, which uses pupil-initiated and maintained experiments as well as inferring, formulating, and testing hypotheses.

Girls, as a whole, favor the enquiry model of teaching, which is most often the style used in biology classes. Physics teachers, on the other hand, usually choose the problem solver or informer mode. Worldwide, many more girls than boys choose to study biology, while more boys elect physics.

In addition, the work of Tobin and others indicates that teachers who use the problem-solving or informing mode frequently identify and interact with target students (Tobin & Gallagher, 1987; Tobin & Garnett, 1987). Study after study shows that the ratio of girls to boys involved as target students ranges from 1:4 to 1:8. Tobin (1987) notes the following differences in the interactive patterns of boys and girls.

- Male students respond to teacher questions by raising their hands more frequently than girls do. (Typical ratio: eight boys to one girl).
- Target students tend to be boys rather than girls.

Such differences occur regardless of whole class ratio of boys to girls, regardless of sex of teacher, and regardless of ability level of the class. For example, Tobin finds that in a Year 11 biology class which contains 12 girls and nine boys, 70% of the teacher questions are answered by the boys. In a Year 9 low ability science class, he reports that boys are identified as all of the target students. Likewise, seven out of eight target students in a Year 9 high ability science class are male (Tobin, 1987).

The study reported in this paper originally addressed two issues: first, gender differences in teacher interactions with boys and girls; and, second, behavioral differences among boys and girls who receive differential treatment. Initially, it was hypothesized that boys and girls would interact differently with each other in a sexist, compared with a non-sexist environment.* Eventually, each member of our research team realized that the behaviors and relationships which lead to a sexist environment are much more complex than those which are easily identified. Indeed, covert, not overt, interactions became the focus of the study.

Description of the Study

Students, who attend Swan Senior High School in a suburb of Perth, enjoy freedom and flexibility in a sprawling, well-equipped school. Visually it is difficult to distinguish the school, the teachers, or the students from their American counterparts. Physically, the school is built in the low, Californian-style of separate units with outside access to and from individual rooms. Although some students wear bits and pieces of the maroon and grey school uniform, the predominant dress is casual and tends to combine jeans with school sweaters. Teachers dress very casually, and the casual, friendly atmosphere is perpetuated by the habit of calling teachers by their first names. Bells do not ring; students pass between classes somewhat casually. There are differences, of course, but they are superficial ones. For example, the accent and slang as well as morning and afternoon recesses for tea are strictly Australian.

Swan is a public school, serving grades 7 to 12. Our international team of five (two men and three women) observed two teachers, one male and one female, who teach Year 10 general science to mixed groups of intermediate and advanced students. We observed both teachers over a period of ten weeks, during two units of study: Vertebrates and Nuclear Energy. The general purpose of our study is to focus on issues associated with teaching for higher cognitive level learning in high school science classes; my

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*"Sexist" is defined as using traditionally sex-role stereotyped examples, humor, roles, or behavior within the classroom setting and by the classroom teacher.

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specific focus is to ascertain if differential teacher behavior toward boys and girls affects the levels of cognitive learning by boys and girls. Although both teachers have been selected on the basis of competence, compatibility, and confidence, we soon realize that they have very different abilities, both academically and socially. Their ability levels as well as their differential treatments of girls and boys produced two different and unique settings for studying interaction patterns which integrate students and teachers into a productive unit. Although both teachers and classes are discussed in Tobin, Kahle, and Fraser (in press), this paper will focus on the overtly sexist classroom of Peter, the male teacher.

Peter initially studied to be a physical education teacher, but he completed his Bachelor of Education degree in zoology and human biology. Subsequently, he has earned a graduate diploma. He is 36 years old and has taught for ten years, including a year as an exchange teacher in Toronto. Married with two young children, Peter appears happy, confident, and stable. He describes himself as independent, conservative, and radical.

Observations and Data

Peter's observed Year 10 general science class consists of 20 girls and 11 boys. Four students sit at long tables, arranged in horizontal rows. Although some table groups are mixed, most consist of only boys or girls. The atmosphere is casual, yet orderly, and students often work together in small groups. Peter, himself, displays two different teaching patterns. In one he is "the captain of the ship," holding forth at the front of the room with a demonstration or using rapid fire delivery to review with low cognitive level questions. In the other mode, he wanders about the room, stopping to assist individual pupils with their work. In both teaching modes, he displays subtle and overt sexist behavior. When a male observer asked Peter why he interrupted studying students to stage a spontaneous demonstration, Peter answered,

> Well, I guess that a lot of my teaching is that I want to interact with the kids....It was my way of stopping the class and pulling eight kids out of the class and doing an activity....It had me, I guess, as the sort of captain of the ship out there directing them and stuff like that. And to a large extent, that's the adrenalin surge that I get out of teaching and being in the classroom. And I am the kind of a teacher who does love to direct them and dominate the kids. I'm a pretty dominating sort of influence. (September 9, 1986).

Peter continues to explain how and why he selected the particular students for the demonstration.

> I tend toward those kids who interact with me....Danielle, Louise Crock, young lass in the front on the left-hand side, Lara, ah, Max Chin, and Kim, ah, Joe, to a lesser extent, ah Rachel. (September 9, 1986).

Repeated observations record that Peter consistently selected the pretty girls and the more mature, masculine boys for activities.

When a male observer queried Peter about the "best" and "worst" students in his class, Peter's nominations as best included the students with whom he interacted regularly. Peter also described the best boys as "smart" and "a real mate," while he mentioned the physical attributes of the best girls. For example, "Lara, she's a lovely girl," or "Peta has beautiful eyes," or "Nicole is a rather gorgeous kid." One girl, Linda, caused constant, small problems for Peter. For example, she asked unexpected questions and she distracted the others at her table. When a male observer commented that Linda was a very capable girl and asked for Peter's perception of her, Peter replied:

> Linda, I think, is very lazy. In fact, I made comments on her report to the effect that she will have to work a lot harder next year, especially taking the subjects she is taking, if she wants to succeed. But, again, I think it is probably a certain amount of personal bias because of her size. I find it disagreeable when kids are as overweight

> as she is, and I find it difficult to understand and appreciate.
>
> (November 13, 1986).

On a first or second visitation, even a trained ethnographer did not pick up the sexist attitudes and behaviors of Peter; repeated observations were required before the patterns became evident.

What are the effects of the observed differential behaviors toward boys and girls? First, although Peter overtly favors girls, one finds that his whole group interactions are primarily with boys, who raise their hands and are called upon to respond to most of the high level cognitive questions. Second, since many of his interactions with girls are on a personal level, academic or scientific competence is not reinforced for even the brightest of the girls. Third, Peter's teaching style which favors the risk-takers and which relies on masculine references (football, archery, sailing, etc.), favors boys, compared with girls.

What are some of the outcomes of a sexist classroom? When students were asked to Draw-a-Scientist, every student drew a white, male scientist who wore a lab coat and glasses. (Peter frequently donned a lab coat and rubber gloves for dissections and demonstrations.) When grades were analyzed, over twice as many girls as boys received marks in the two lowest categories (intermediate credit and intermediate pass). When students from Peter's class selected their upper school science electives, their choices reflected the sex-role stereotyping, which was typical in his classes.

Enrollment Data

Subject	Female	Male
Physics	3	10
Chemistry	7	13
Physical Science	2	4
Biology	8	7
Human Biology	20	4
No Science	0	5

These data are particularly disturbing since all tertiary institutions in Western Australia require chemistry and physics for entrance into any scientific or technological degree program (except medicine).

Concluding Thoughts

Peter was, and is, an anomaly - a dedicated, well-intentioned teacher - who disadvantages both girls and boys by the overt sexism in his teaching and classroom. Peter thinks he favors girls, but the above data indicate that in reality his treatment encourages boys. When I asked him if he did anything different with girls in order to keep them encouraged and interested in science, Peter replied:

> I like to take a personal interest in girls more so than boys, because I am basically a heterosexual sort of a person, if you know what I mean. I am attracted to girls, and I think that is sort of the normal way it should be. The other side of that, with respect to the boys, is that I often have a sort of a mateship which I establish with a lot of the boys. I walk up to some of the boys and thump them on the back, or I drop my shoulder and bump them. And a lot of them will drop their shoulder and try to bump me back. I can't do that with the girls. You can't thump a girl on the back. You see, that is missing in the relationship you have with girls. I will often compliment a girl on how she is dressed, but you don't compliment a boy on how he is dressed. (November 11, 1986).

Study after study notes that girls are encouraged in science by seeing it as a normal endeavor for women and as part of a routine, career expectation (Erickson & Erickson, 1987; Kelly, 1985; Kahle, 1985). Peter's behavior clearly indicates that girls are "different." Although Peter thinks he favors girls with frequent, positive interactions, in reality his acceptance of boys as equals favors them. The advantaged female in Peter's classroom becomes the disadvantaged person who sees no option nor place for herself in non-traditional scientific or technological courses and careers.

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GENDER AND KNOWLEDGE IN ENGINEERING EDUCATIONS

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Abstract.
Very often the question has been raised whether women do develop another kind of technique than men? We can not answer this question because women have not yet had any influence on the technical an technological development. How are we able to develop knowledge, technique and technology when there is a barrier stating that traditional female values are defined as non-relevant technical knowledge.

In this paper I am dealing with the question of defining what today considered relevant technical and how to change relevant technical knowledge to include female aspects.

Knowledge forms the basis of technology.

Knowledge forms the basis of technology - in simple words: without knowledge there would not be any technological renovations or inventions - and subsiquently no progress. Therefore it is necessary to uncover the kind of knowledge that is beeing used in the engineering educations.

A basic definition of knowledge contains experience, intuition and recognition. A traditional definition of the concept of knowledge in the engineering educations is the technical knowledge. Working engineers would say that economic and human knowledge is necessary too, but these are rarely part of the general formal qualifications in the educations.

The concept of technical knowledge includes knowledge from different levels: (1)

1) A basic scientific level where scientific research exists.
2) A construction level where applied science and technical science are linked together and the principles of technical inventions are verified.
3) A production level where realization of the technical inventions and innovation take place.
4) A users level where practical experience from use of technical inventions and innovations may be collected.

The total concept of technical knowledge includes experience and recognition from all four levels. These four levels are incorporated in, and part of, each other and development on each level is always dependent upon knowledge gained from the other levels. The level of construction is dominating in engineering educations, but we also find the basic scientific level presented as part of applied science. We also find knowledge from the two practical levels, production and users, incorporated in the construction level.

The concept of technology.

There is a difference between technique and technology. Technique is an element of the concept of technology. Other elements are competence, organization and product (2). *Technique* is a means of reaching an objective - often it is one or several tools which are developed to support different parts of the working process. *Competence* contains three aspects: 1) knowledge of construction, 2) qualifications necessary for using the technique and 3) qualifications developed through use of the technique. *Organization* contains both a socially and technically determined organization. Though the product always will be the purpose of the technical process the structure of the product is different and dependent upon the choise of other elements. A beer is not only a beer, but a result of the whole technological process which include and choise of technique, competence and organization.

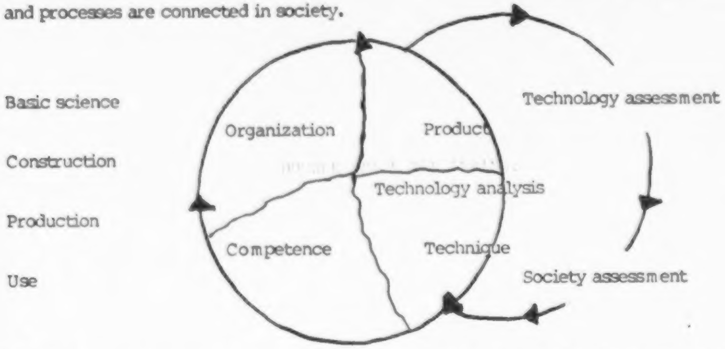
Traditionally is knowledge and qualification in engineering educations defined as technique as though realization of technical inventions always depend upon other elements which are included in the concept of technology. Therefore it would be relevant to learn about these other elements in the educations as well learning to make assessments of society and technology.

Technology analysis and assessments.

The above four elements are not only parts of the concept of technology, but also the basic elements in a *technology analysis* which concerns the practical development and maintaining of a certain technological process. Technology analysis does not only concern the knowledge levels of production and use of technology, but in fact also the construction and basic scientific levels. If a certain product does not serve its purpose, it might be necessary to develop further knowledge, qualifications, organizational structures or techniques. Then we are back to the construction and basic scientific levels for new knowledge.

Technology analysis is closely connected to *society and technology assessment*. Society assessment points out technological needs, purposes and objectives. Society's theoretical and methodical stand point determines the type of purpose that will be pointed out. There is a difference between the energy needs that attaches importance to non-pollution and a short-term cheap energy supply. There is also a difference between a wish for a better health and a wish for a medicotechnical instrument. A choice of different needs will influence on the choice of the elements in technology and will determine the technological process and development.

Theories and methods in technology assessment will have consequences for the character and content of the assessment. Most often the reactive technology assessment is used when consequences of the technological process and a developed product is analysed. We rarely see a proactive technology assessment of technological process and a certain product that has not yet been produced, but only exists as a theoretical idea. The proactive technology assessment is a much more difficult process of research, because it demands a holistic view of how different structures and processes are connected in society.



In short I would illustrate the connection between the concept of technology, society- and technology assessment and technology analysis. It is important to remark that the belowed illustration must be used on each of the four levels of knowledge to become a technological knowledge.

Technology as knowledge and qualification.

The recent involving the concept of technology with defining knowledge and qualifications in engineering educations is the question of relevant or non-relevant knowledge. The traditional technical knowledge concerns all levels of knowledge and even a kind of society- and technology assessment. However, these primarily consists technical knowledge, capitalistic, economical and political needs disregarding to a humanistic theories and methods.

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By involving theories of technology as a basic framework for engineering/qualifications and knowledge, I focus on the connections and relations technology may concern. Technique is not an isolated part of reality which the inventive genius may concentrate on. Technology will change structures and processes as well in society as well as in the human's everyday life.

By changing the concept of engineering qualification from a technical culture into a technological culture it opens a possibility to include knowledge of theories and methods in society and technology assessments. This will be the new relevant knowledge - and I would call it technological knowledge. To be interdiciplinary means not only to work together across scientific borders, but also makes necessary a development of scientific intergration in oneself. Then it will be possible to build up a common understanding of different concepts - to be able to work together across scientific borders. This is bridgebuilding between humanism, social science and science.

Being interdiciplinary does not mean that an engineer must become an expert in social science, but it means that she must know enough about social science to have a fruitfull working relationships with social scinetists. The knowledge contains in above theories of technology would make a interdiciplinary relationship possible.

Social femininity, knowledge and visions.

Changing the concept of relevant knowledge into basing it on theories of technology is necessary to incorporate female values. To ask if women do develop another kind of technique than men is a question that has no answer, because men have dominated technological development of all levels of knowledge and are responsible for the way we construct f.ex. a radio. Women would not be able to construct this in any other way. However, women might not have developed the radio - I don't know - and I don't think it is an important question. What I find more interesting is the question, if women might develop another technology. It would not be possible to answer this question either, because the elements in the concept of technology are as yet rarely part of the formal qualification. However, this question is more relevant, because it opens up the possibillity of intergrating other values in technology, values that not only consider technique itself.

In recent years there have been several discussion regarding the contents in femininity and female values. I will refer to my own conclusions on this subject (3). In short, I find femininity is a social concept, dependent on psychological evolution, society, patriarchism and history of life. Society's progress has made a hierarchial and reductionary dualism between the social masculinity and social femininity - in society as well in individuals. Both men and women contain social femininity and social masculinity, but history of life and society have suppressed a conscious knowledge of both qualities and the intergration of these to create new values. When women enter into male dominated areas they will meet values of the social masculinity in creation of knowledge and organization. Some women are geniouses and are able to intergrate these values with her own without any problems. However, we are not all these kind of geniouses, and there must be room for all women to develop strategies inabling them to intergrate male and female values. If room is not given problems will araise on both an individual level as well in society. Social femininity has a function as a identity and personal values to individuals and as f.ex. caring for social relations in society. There will be a gab if women enter into maledominated areas without bringing along their values. It is therefore important to open up the concept of knowledge to include experience, recognition and intuition refering to social femininity.

To intergrate technical knowledge and social femininity demands progress and to comprehend the intergration we must understand it as development. I have drawn up three stages of development: (4)

1) Social ideology which should show a picture of today. It is a reductionary dualistic picture of what relevant technical knowledge is. I don't like this black and white picture myself, because it gives a reductionary picture of a reality which is much more complicated and full of nuances and diversities. Therefore it is just a starting point to illustrate the ideological reality.

2) Strategies towards a vision. I havn't made any concrete strategy, because I think first step is to learn unthink our way of traditional comprehension and think something else (5). It's a necessary method because we are used to think in dualism an unused to thinking in a holistic way. A concrete strategy would include changes of curriculum and pedagogic.

3) A vision of future knowledge in engineering. It is not only a question of intergrating female and male values but transcending into new concepts of reality. Therefore it is necessary to learn unthinking and rethinking as a strategy.

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Ideology

Relevant technical knowledge	Non-relevant technical knowledge
Social masculinity	Social feminity
Dominate nature	Be a part of nature
Linear	Spiral
Technical economic rationality	caring rationality
Undependent recognition	Dependent recognition
Objective	Subjective
Hierarchical	Non-hierarchical
Logic	Emotional

Strategy

Unthink traditional way of thinking

Rethink with all senses

think something new

take courage to talk and act

Vision

Complete technological knowledge

Intergrate and transcendent

Social masculinity and

s. femininity

Respect of nature as basic

Existens

Dynamic

A whole rationality

Holistic recognition

Dialistic

Equality

Respect and acceptance

I have called my vision complete technological knowledge. It is a concept not only containing technological qualification defined by the concept of technology, technology analysis - assessment, but also including the transcendend and intergrated femininity and masculinity. In general theories of technology do not include questions of gender, nor a feminist perspective including both male and female values and regard to the sex division on the labour market. Therefore it is not only changing the technical knowledge into a technological knowledge and qualification, but also a change on behalf of a feminist technological concept.

Where are we now?

A feminist technological concept has to be developed and will contain development of a feminist perspective to all the levels of knowledge. The scientific paradigms have been critizied by Evelyn Fox Keller (6) who says that we must open up the laws in science and change them into rules. One condition is that the scientists themselves change and intergrate recognition and emotions. Isabel Stengers (7) agrees to this and says further that scientists learn to cheat by closing up the research process, forgetting all kinds of questions and doubtfullness and only presenting certain questions that they know can be answered. Mobilization in the scientific world close up the scientific results. Brian Easleay (8) states that female values may exist in the process but are eliminated in the presented result.

All these scientists have focused on the basic scientific level. Other feminist researchers have been working with women as users of technology - the two practical levels. Technology assessment of automation processes in offices has been made, of domestic work and time used, of the birth process and surely several other areas of womens life.

There has also been analysis of women's situation on a level of construction. These investigations have mostly uncovered women's strategies towards a male dominated area and havn't been dealing with the question of female knowledge and qualification. To get any further in theories of technology and in the concept of knowledge, we must enter into this level developing a feminist perspective on construction. This is our new challenge.

I say this based on our experiences from engineering education at University of Aalborg. There we have the project organized and interdiciplinary studies. We teach in how to make analysis and assessments of society and technology in the first basic year. But we are not on a visionary level - on contrarary we deal with the question of relevant technical knowledge. The traditional engineer throws away theories of technology as emotional toys. Perhaps because society assessments may threaten the "irrational feelings of joy and fascination connected to the technical construction". Perhaps he one day wakes up - thinking over what is rational and what is irrational and that other kinds of knowledge do not threaten his joy of developing technique, but only questions if it is a relevant choice of technology and future.

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1) My inspirations for theories of technology come from discussions in "Department of Technology and Society", University of Aalborg. Special two references are important: Jens Müller, Arne Remmen and Per Christensen: "Samfundets teknologi", Systime 1984, and Per Christensen (editor): "Mod en helhedsorienteret teknologiteori", University Press of Aalborg, Denmark, 1987.

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THE UNIVERSITY NEEDS WOMEN,IT JUST DOESN'T KNOW IT YET

NINA KOPOLA ,MIRJAM LUKOLA

ABO AKADEMI DEPARMENT OF ORGANIC CHEMISTRY

Abo Akademi is a small university, with about 5000 students, divided on 5 faculties. The total percentage of women is 58 %. This study will concern female students and graduated from the faculties of chemical engineering and science. Special emphasis will be given to students who have chosen chemistry as their main subject.

The percentage of women in the faculty of chemical engineering has traditionally been low, rising from about 2% in 1970 to 20% today. In the Faculty of natural science women are 50% of the total.

As base for this study we will use an interview with two groups one of students and one of graduated women from both faculties. The women in the groups are fairly young, with work experience varying from one to five years. The students again were from the senior classes. The interviews were made in free form, more like discussions. The subjects touched on were concentrated on how they experience their work place and how they feel about themselves as women. We will also go further into these topics in a discussion part.

Although the percentage of of women between these faculties differs that much, we could not see any difference in the attitudes.

As the authors represent both of these classes a personal view on the matter will be given. We hope to give some new aspects and thoughts for the future.

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CAREER PLANS

The questions asked were about childhood dream careers, why they had then chosen the field they were in now and what plans they had for future.

Most of the dream careers were academic ones, typically medical doctor, dentist or veterinary.

It also seems as chance has had great influence in the final decision, very many women had changed subjects during their education. Few could give straightforward answers on why they had chosen to become a chemist or an engineer. In some cases there was an obvious correlation to the parents education, but not in all.

> "In our family chemistry goes in the family"
>
> "Veterinary, but then I got allergic"
>
> "I was interested in mathematics and chemistry in school, so I chose chemistry"

Very few had definite careerplans. Most of them thaught that they couldn't influence in their own careers. Their first employment was something they just got into. Some of them even said that they did not have the right to choose.

> "You may never say you have chosen, in principle you can not choose"
>
> "Your first job you cannot choose! It's more good or bad luck if you become a researcher or a salesman"

The students plans for the future were even more diffuse.

> "No, I have not yet any goal. I'll first have to take the job I'll get"
>
> "As women my chances are not very good to advance or then I'll have to devote myself totally to the career"

A common opinion was also that the first job was likely to be somewhat below your capacity and that you would be able get "good" job only after one or two employments. They found it very natural that they could not define the kind of jobs they really would have liked to have.

> "It is a milestone to graduate, you will then see much clearer"
>
> "Often you want to get your first job and then start thinking"
>
> "You'll know after a few employments what you want to do"
>
> "You are almost forced to take the job you can get"
>
> "You must not give up, you have to fight on"

To the question of if the job was satisfactory and if they could use all their capacity, only one answered she was really content, she was the one who really had the strongest ambitions.

> "I decided the job I wanted already during my studies 4-5 years before I graduated"

The others felt they could handle more responsibility. Some also found that they could not use all their capabilities, but did not see this as a reason to change employment.

The next item was about how they felt about themselves as chemists and engineers. They had great difficulties to give any answers, some of them were totally confused.

> "You seldom think of such things as a professional identity"
>
> ""I don't know I have worked for such a short while"

When asked if they were different from their male colleagues, the students had strong opinions. They found the boys much more self-assured and tough They also thought that boys had clearer visions for the future.

> "A woman chooses a job she knows she can manage, when a man chooses a job a little above his abilities capacity".

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"Yes the boys are much more self-assured. they believe they come to the top straight away"

"Women cannot boast, they do not know how to be tough"

Some distinct differences between the sexes in the way of thinking were also mentioned.

"Women usually think on all matters at a time and men separate between things. They can think only on work and then switch of to the private life"

"My male colleagues have better capabilities to leave the private life outside the work"

"Women are more practical than men"

The graduated didn't want to see any differences. They thought that there are just good or bad chemists and engineers, they couldn't see any correlation to the sex. It was also very difficult to give qualifications for a good engineer or chemist. Some of the suggested ones are: accuracy, coping with people, organizing abilities, being a good leader. It was also suggested that women who choose these occupations are more straightforward and intelligent than traditional ones.

WOMANHOOD:

That there exists some kind of conflict between the role model for a woman and a female chemist or engineer is shown by the difficulties in answering questions about their own feminity. Most of them thought that feminity was something negative and couldn't accept any of it in themselves. Some of them even thought the only female characteristic they had was to give birth to children. In this matter the graduated and the students gave similar answers.

"I have never felt like a woman"

> "I am active not passive"
>
> "I have male characteristics"
>
> "I always thought that something feminine is negative"

A typical woman for them had high heels and a pudel sitting on her lap. She is also very stupid. Some kind of softness was one feature most of them could accept as typically female. Almost no other characteristics were mentioned. Most of them held to their opinion that it is more a question of personality. They motivated it with having both caring mothers and fathers among their colleagues.

> "It is diffuse what you mean by female characteristics. I believe it is more a question of persons. I try to be objective"

None of them could accept to use their female characteristics in order to achieve something.

> "I have never used such tactics"
>
> "If you are the type you surely can use it"
>
> "There are people who want to get that sort of attention"

It was also thought that you had to accept mens behaviour, their dirty stories. If you did not do so, you were thought of as inferior or lacking humour.

> "If you have gone through this education, you do not blush when hearing dirty stories"

Most of the students wanted to have children. They were also very aware of the conflict it can create but none of them planned to choose career before children. It was also suggested that you should bear your children while you are studying, it would then be easier to get employment. Some said it was never the right time to have the children.

The graduated again were more vague in their opinions, although all of them are in the typical childbearing age. They hadn't made their decision yet.

"It is a conflict. I do want to have children, but I also want to make a career"

"I do not know if I want to have children, if I do it will be a conflict"

"I usually plan everything very carefully but this I have not scheduled.

"The older you get the greater the chances for having a handicapped child. It will be a conflict anyway"

Nobody felt herself directly discriminated and their sex had never been abused in any way. They did although give some examples of friends who had had the experiences.

The graduated were often the only women at their job and thus could not feel any solidarity with the women they had contact with, they couldn't see collaborators as colleagues.

Neither did the students feel much solidarity among women.They found women almost dangerous. When comparing female and male competitor it was also worse to loose a competition to a woman, because then you were really incompetent. It was also easier to accept a male chief.

"You are not you loose to a man it is normal that he is better"

DISCUSSION

When we looked upon the dream careers it seemed as those where caring aspects are emphasized were in majority. This is in line with what is thought to be typical female occupations. It could be that as most of the questioned women had academic parents, they dreamt of becoming doctors instead of nurses. At some stage they abandoned these dreams and became students of natural sciences and technology. It is also

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remarkable that almost all of them have changed subject at least once. This points to a lack of exact ambitions.

It seems as the women would not dare to make any definite plans for the future. It is difficult for them to see themselves in a longer perspective. The lack of positive role models is most propably a contributing factor. As one said;"When you say engineer you think of a man". Where do you place yourself as a woman and engineer when such statements are true?

One reason why the graduated women where more vague than the students in their answers to the question of having children may be a more strained situation. They are older and much closer to the point when you finally have to decide if you want children. Their careers are in the beginning and they thus have much more to loose. Most of them said it was almost impossible to have both, interesting job and children. They seemed to want to close their eyes and just not think about it. Some of the students had not yet decided if they wanted to have children. The fear of having to take all the responsibility for the children could also lead to this uncertainty. As a solution to this they saw a shared parents leave. This would make them equal both in the family and in the society.

It is astonishing that the graduated do not recognize any difference between themselves and their male colleagues. They rather saw their male colleagues as persons without any correlation to the sex. It is as though there existed only one role model for an engineer or chemist. The difference being between good and bad ones, not men and women. It is then natural to adapt the role of the good chemist, if you do not do so it is hard to survive.

We claim that there are several different ways of being a good chemist.

Women have many new aspects to bring into chemistry and technology. Today womens values are totally lacking although they present an invaluable source for recreating working society. Women act in a more holistic way, not separating private life from the rest and not separating the work that has been done from the person that did it. They thus also carry more responsibility as human beings for humanity. These characteristics are essential for the developpement of technology, today they are being suppressed.

Another consequence of adapting yourself to the male role is loss of female identity. This is very much brought up in the discussion of feminity. As in their eyes female characteristics were negative, it is natural that you do not want to have them yourself. When the model is so stereotype you cannot dare to be mixed up with the feminin stupid woman. This ambivalence might lead in to a very awkward situation, where one is not belonging to neither the women's world nor to the men's world. It is almost a sexless existence. If women had the possibility to discuss these matters they would be able to find a better way to express their womanhood, without any risktaking. In our opnion it is important that women would become more aware of these existing problems. We also believe that women networks would give an opportunitie for exchangement of experiences. The need for getting together was recognised among all the interviewed women.

There will not be any change in attitudes before women feel free to express all sides of themselves in these fields. We believe that such a change would alter technology and lead to a more secure society.

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DIFFICULTIES WITH DIFFICULTY

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It has been suggested that one of the factors which affects pupils' choice of subject is their perceptions of subject difficulty. Indeed Ormerod (1981) has cited the difficulty of the physical sciences as a major reason for their rejection by girls. He suggests that subject preference rankings are strongly related to perceived difficulty ranking for girls but not for boys, and that subject preference is more highly correlated with perceived difficulty than with attainment. In an earlier discussion (Ormerod and Duckworth 1975), it was argued that Physics and Chemistry are more difficult than other school subjects both in terms of pupil perceptions and of the cognitive demands made by these subjects.

Another factor which might at first sight appear to be related to pupils' perceptions of subject difficulty is their self-confidence within a subject, and this is discussed in the HMI report "Girls and science" (1980). Both these factors were therefore considered in the design of a study of 13-14 year old girls and boys in practical subjects such as the sciences and technology. The results of a questionnaire showed that difficulty is not an unambiguous term, and that relationships between these constructs may not be entirely as expected.

The questionnaire was an opinion questionnaire, in which pupils were asked to answer the same questions about each of several subjects. This made it possible to compare their responses to different subjects as well as to compare boys' and girls' responses within subjects and to assess the relationships between different factors. A full attitude questionnaire was not used, as a number of attitude scales in each subject would have resulted in an inordinately long questionnaire. In addition it can be argued that attitude scales themselves impose an artificial unidimensionality on multi-dimensional constructs. Items are usually included on the same attitude scale when they have a sufficiently high correlation with each other, but surely it is a matter of philosophy rather than of statistics to decide whether they are different ways of saying the same thing, or whether they are really different things which happen to be related. Most questions [illegible] items, had a set of five Likert-type responses [illegible]

This research was carried out at two schools, but differences in the subject allocation and ages of the children made it inappropriate to combine questionnaire data for initial analysis. The small number of pupils in one [illegible] made it difficult to attach significance to correlation coefficients which would account for up to [illegible] of the variance within either sex were insignificant. Results from this school are therefore omitted, although individual response patterns from the school appeared to support the arguments below.

At the other school, 41 girls and 27 boys aged 13-14 completed an initial questionnaire, which meant that a non-significant correlation for either sex would not usually account for more than about [illegible] of variance. The questionnaire was given at the start of the spring term, before the subject option choices had been made and before pupils were told which subject combinations were or were not possible. (Some may have known at this stage that they were obliged to choose at least one of Physics and Biology.) A final questionnaire was given two terms later but had fewer respondents because of difficulties in collection at that stage in the school year.

The questionnaire included two questions relating to difficulty:

"How difficult do you expect to find this subject in school?", and

"How difficult do you think this subject is for most people?"

This was a consequence of a pilot study, in which a small but noticeable proportion of children had given different responses to what were thought to be alternative forms of the same question. Further questioning of these children seemed to indicate that the main discriminant was whether the question was interpreted as referring to difficulty for themselves, or to difficulty for people in general. [illegible] was therefore [illegible] to [illegible] any differences. [illegible] the questionnaire were "How good [illegible]", questions about [illegible]

[illegible]

subject. As might perhaps be expected in this case, self-assessments of ability are not correlated with difficulty for others in any subject, but, perhaps more surprisingly, neither are they correlated with difficulty for self in most cases. The only one of these questions which is consistently correlated with prospective subject choice is self assessment of ability, although difficulty for self is moderately correlated with choice for boys in Biology and girls in Technology and Home Economics. The only combinations for which the correlations between difficulty for self and self-assessed ability are significant [illegible]

TABLE 1: CORRELATIONS BETWEEN DIFFICULTY AND ABILITY ESTIMATES

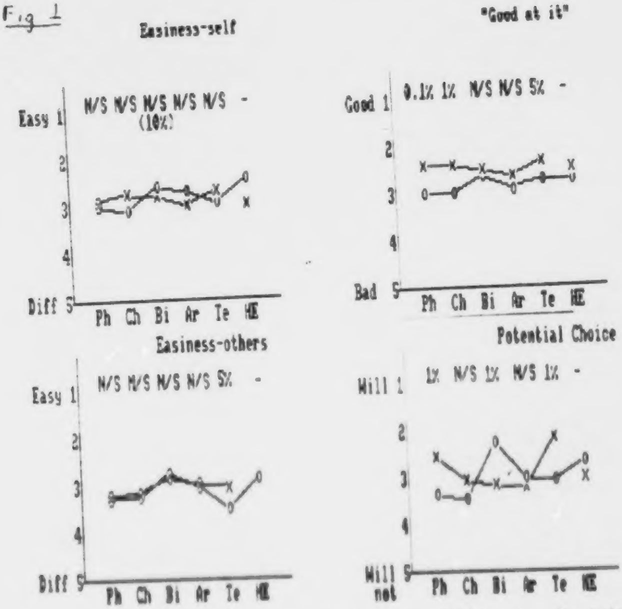
	Physics		Chemistry		Biology		Art		Technology		Home Economics	
	G	B	G	B	G	B	G	B	G	B	G	B
Easy-self/ "Good at it"	-.26	.25	.19	.25	.13	.34	[illegible]	[illegible]	.41	.20	.42	-
Easy-others/ "Good at it"	-.04	.05	.00		.14	.12	[illegible]	[illegible]	.11	-.01	.17	
Easy-self/ Easy-others	-.06	.05	.38	.41	.38	.47	.32	.42	.11	.43	.27	-
N	42	37	42	37	42	37	42	36	23	36	27	4

TABLE 2: CORRELATIONS WITH SUBJECT CHOICE

	Physics		Chemistry		Biology		Art		Technology		Home Economics	
	G	B	G	B	G	B	G	B	G	B	G	B
Easy-self	[illegible]	.26	[illegible]	.29	.14	.32	.29	.04	.41	.14	.48	-
Easy-others	.14	.22	-.02	.11	.01	.25	-.11	-.13	.01	.27	.18	-
"Good at it"	.34	.31	.52	.31	.32	.34	.42	.38	.46	.27	.30	-
N	42	37	42	37	42	37	42	36	23	36	27	4

Fig 1 shows the sex differences in mean responses to each of the questions under consideration for these school subjects. It is apparent that, although boys have higher opinions of their own ability than do girls in each subject, this difference being significant for Physics, Chemistry and Technology, they do not find these subjects significantly easier than do girls. In addition with the exception of Technology, there is no difference in

Fig 1



perception of difficulty for others. The differences in potential subject choice, however, follow the usual pattern.

These results may seem surprising: it might at first thought be expected that those who think themselves less good at a subject would be those who find it hardest. As these results show, however, the relationships between these constructs are more complex than that, but there are a number of positions that people can take, which would result in different response combinations. Of course it is possible to think:

"This is an easy subject for me and everyone else, and I'm good at it" or, conversely:

"This is a difficult subject for all of us and I'm not very good at it"

Another possible position, however, is:

"I think this subject is difficult for all of us but I still do quite well at it". or alternatively:

"This is quite an easy subject for all of us" (in comparison with other subjects, perhaps) "but I am not particularly good at it" (in comparison with other pupils, perhaps, or with my marks or position in the class in other subjects).

A position reflecting high self esteem might be:

"Most people find this subject difficult, but I'm good at it as I find it easy" whereas a pupil with low self-esteem might feel that

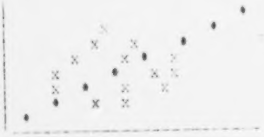
"Most of the others find this subject quite easy, but I'm not very good at it and I find it rather difficult."

Other positions are also possible.

These positions, all of which have some consistency, indicate the variety of possible relationships between apparently similar constructs as well as the variety of meanings which can be attached to the term "difficulty", (e.g. difficulty for self, difficulty for others, difficulty in comparison with other subjects, difficulty for self in comparison with others etc). It is not, therefore, easy to assess reports on difficulty unless the actual questions used are reported. In the case of Ormerod and his co-authors the present writer has yet to find a report which gives the wording of his questions. If, of course, the question used is a general one such as "how difficult is this subject", it might be that different respondents interpret the question in different ways, thus giving a confusing picture.

It is also apparent that the relationships between difficulty, self-estimated ability and choice vary with subject as well as sex. This could be misleading if attempts are made to group questions into attitude scales which are not subject specific. If pilot studies made for this purpose cover several subjects then a moderate overall correlation between two questions might mask large correlations between these questions for some subjects coexisting with small correlations for others (see the diagram, in which points marked • are highly correlated and points marked x have little correlation). If such pilot studies are subject specific then attitude scales which are valid for some subjects are not necessarily valid for others.

These, then, are some of the cautions that should be applied when interpreting results concerning subject difficulty. What conclusions can be drawn from the results given?



Certainly it does not seem possible to conclude that girls reject Physics and Chemistry because they find them difficult (although this may be a factor in their rejection of Technology). The girls in this sample found the physical sciences no harder than did the boys, and difficulty was not related to their choice of these subjects. They do, however, consider themselves less good at these subjects than do boys, and this is firmly related to subject choice. These results are, therefore, consistent with the hypothesis that girls show less self-confidence than do boys — a hypothesis suggested or supported by a number of writers (eg Beyer et al [illegible], Fennema

1983, Licht and Dweck 1983, Maccoby and Jacklin 1974 (p41), Simpson, E. 1983, Sorensen 1983 etc.). Simpson (1983) found that the difference between male and female estimates of their own ability among college freshmen was highest for the highest ability students. In this context it is interesting to note that it was only among the highest ability pupils (a group of 12 boys and 15 girls) in the present study that girls found Physics and Chemistry harder for themselves than did boys (p<5% for Physics and p<1% for Chemistry). Girls in this group rated themselves as highly as the boys in these two subjects, however, and most of the girls who finally chose Physics or Technology were from this group.

What then are the practical implications of these findings? It might be suggested that more girls would be attracted to Physics if it were made less difficult, but the girls in this study do not in general appear to find it any harder than do boys. If it is true that the cognitive demands of Physics at this age are higher than those of other subjects there may be a case for making Physics easier for the benefit of all pupils, but to do this primarily to attract girls is likely to reinforce the views of those who believe that girls are not capable of doing this subject at the same level as boys. Even if Physics were made easier, there is no guarantee that girls would begin to consider themselves as good at the subject as boys do; it has been seen that there is no correlation between perceptions of difficulty and perceptions of pupils' own ability for the physical sciences.

What needs to be done is to give girls confidence in their own ability at these subjects, and this is an area in which the classroom teacher can play a part. Not all measures intended to do this will necessarily have the desired effect, however, and there are several areas of research which can inform this.

Licht and Dweck (1983) review some of the large volume of work by themselves and others on attribution theory and learned helplessness. Attribution theory suggests that girls tend to attribute their successes to external factors such as luck and their failures to internal factors such as lack of ability, while boys tend to attribute their successes to internal factors such as ability and their failures to factors such as bad luck and insufficient work. The condition of learned helplessness, which Dweck suggests applies particularly to girls, is created in animals or humans when reinforcement is unaffected by a subject's responses. It is as likely to be induced by indiscriminate positive reinforcement as by a total lack of reinforcement or by indiscriminate negative reinforcement.

Dweck and Licht (1980) discuss the patterns of feedback given to boys and girls, in which boys receive more negative feedback but much of it is addressed to nonintellectual features of the work, and boys are more likely to be criticised for a lack of motivation. This makes it easier for boys than for girls to learn to attribute their failures to factors other than lack of ability. Walden and Walkerdine (1985) report that girls who were seen as lacking in confidence in Mathematics were protected rather than pushed, being allowed to "go at their own pace" (slowly) and entered for a less stressful but less prestigious public examination. The course they followed was disliked by boys, who found it babyish, although girls liked it because it made them feel safe. Thus efforts to help less confident pupils also tended to maintain that lack of confidence. Classroom observations reported by Randall (1985) suggested that in some CDT lessons girls are engaged in more teacher-pupil interactions than boys during practical work but that many of these interactions involve girls asking what to do next, or how to do it. These procedures had already been demonstrated, so such questions could be interpreted as showing a lack of independence or of confidence in their memory or understanding of the procedures. Walden and Walkerdine also discuss the way in which characteristics seen by pupils as feminine can lead to teachers dismissing a girl's success as due to hard work whereas "masculine" characteristics, such as the willingness to challenge rules given by the teacher, are taken as evidence of "real understanding". Spear (1981) found similar attitudes in science teachers, whose ratings of scientific accuracy and understanding principles shown by written work were higher if they thought it was written by a boy.

These research results suggest that, while positive reinforcement is of value in increasing girls' confidence, it should not be indiscriminate and should praise the girl's ability and not only refer to peripheral factors such as neatness or reinforce any belief that luck is involved. In CDT, of course, it can be made clear that neatness is an integral part of skill in practical work, so that girls who are neat are therefore better at the subject. It may be counter-productive to be too kind, however. Girls need to be stretched, and to be urged to make an effort to overcome difficulties, although the teacher needs to be alert to the possibility of misunderstandings that the girl is too shy to ask about. When help is requested, it can be given in a way that encourages independence rather than dependence. Thus, rather than answer a question the teacher could ask one or more questions which lead the girl to realise that she can work out the answer herself; rather than do some of her practical work for her the teacher could describe the process verbally or demonstrate it with spare materials, or ask her what she thinks ought to be done next (Randall 1985). Of course it is recognised that, in a lesson where there are many demands on a teacher's time, this approach may take longer. Teachers could also consider carefully what behaviours they consider to indicate "real understanding" so that they do not give a double message. If, for instance, they consider rule challenging to be such, they may need to make it explicit to the girls (and perhaps to themselves) that this will not be classed as disobedience.

If valuable for girls, such treatment is also valuable for boys, but the research quoted seems to suggest that boys already receive feedback which is more likely to produce confidence and independence. A deficit model, i.e. that it is girls who are at fault because they lack confidence, is not intended. In fact mistakes caused by overconfidence, particularly when not acknowledged as such, can be as problematical as underachievement through unwillingness to attempt things because of a lack of confidence. Self-confidence could be taken as a measure of the value an individual places on her/his abilities and other characteristics, and is of course greatly influenced by the value placed on these characteristics by society and communicated to the individual. If girls' abilities and the "feminine" characteristics which they are socialised into exhibiting are valued less by others than boys' abilities and "masculine" characteristics, then the deficit is on the part of a society which teaches girls to undervalue themselves.

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WOMEN'S INTERESTS IN ENGINEERING

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SUMMARY

In this paper it is argued that an interdisciplinary, project-oriented approach in engineering education most likely will attract more women to engineering. There will be given arguments based on research on sex-different interests among secondary school pupils and arguments based on interviews with female engineering students. An interdisciplinary, project-oriented approach could meet the specific interests of women, and therefore increase their participation in engineering education.

INTRODUCTION

Women have a strong minority position in engineering education. The cause of this phenomenon is very complex. One important aspect is the general segregation of labour between men and women in society and the different socialization patterns of girls and boys. However, another aspect ought to be sought in engineering itself. Engineering has been developed in a direction in which most women do not feel attracted to it.
It can be said that the historical developments of women and of engineering are divergent. In order to bring these two together, not only women ought to be changed (e.g. through non stereotyped socialisation) but also engineering should be changed.

Nowadays, the 'official' ideology is that women can do as well as men in all fields. However, the fact that nowadays only 1% of the mining students, 1% of the electronics-students and 4% of the mechanical engineering

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students are female) is illustrative for the weight of the historical burden we still bear. The idea that for instance electronic engineering is not very appropriate for most girls is still present deep in the head of many people, parents, teachers , school-counselors, etc.

But a new dilemma is formulated. There are also many people who believe girls can do engineering as well as boys, including most girls themselves.[1] But the problem is the girls don't choose engineering, they each individually think they cannot or will not do it. Collis (1985) formulated this paradox for girls and women: "We can, but I can't". The other side of this dilemma is, "We can do it, but I won't".
In other words, there is a growing group of women and girls who are aware of the limitations of the historical given traditional female rolemodel, but still don't choose typical male fields like engineering. The crucial question now is 'why don't these women choose careers in engineering?' In answering this question it is necessary to draw the engineering itself into the analysis. I will argue that next to the perceived lack of abilities also the lack of interest in engineering, at least engineering in the way it takes shape nowadays, is responsible for keeping girls from studying engineering. Engineering education is still mainly based on the interests of men. Several research results show that girls at secondary school have interests that differ from the interests of boys. Differences in interests between boys and girls were also found among the engineering students, although this group only holds a selected group of girls.

GENDER DIFFERENCES IN CHILDRENS INTERESTS

Research among 13-year old schoolchildren showed a remarkeble difference between boys and girls in their images of technology (Raat & de Vries, 1986). Summarized, it can be said that the image of boys was much more differentiated. Girls often gave an anwser like "that is something with electricity" . Boys could distingish different fields of technology and often gave definitions. This difference can be explained by the greater distance girls have towards technology, they have less practical experiences. Girls show less interest in the subject technology.
However, gender differences in interest can be found much younger age. An illustrative example is a project where 8-years old children were asked to make a drawing about warfare. Boys made drawings with a lot of war-

machinery, like tanks, rockets, jet-planes etc. They could draw them with much detail. Human beings were only little figurants in this portrait of technology. Girls on the other hand, almost all made drawings with the persons (soldiers) central in it. Most drawings presented dead or wounded soldiers. Sometimes they drawed machinery but in most cases these were only very global, not detailed.

One can conclude from this research that at the age of 8 girls are already much more interested in the human aspects and boys in the technical aspects of warfare, but probably also of other domains. This gender difference in human-orientation is also found at older ages.

GENDER DIFFERENCES IN INTERESTS IN SCIENCE COURSES

In research at the level of secondary school two important aspects of differences in interests came out. First, the intrinsic value of science - that is the personal satisfaction and personal development that they get out of the different aspects of doing science - differed for boys and girls. Secondly, the importance of the social usefulness of science differed for the sexes.

Intrinsic value

Research in the United Kingdom (HMI, 1980) found out that girls at secondary school often reject physics because it is too much object-oriented. Besides this, girls often point at the problem that it is almost not possible for them to form personal opinions in physics; they cannot integrate their own personality in it.

Diverse researchers find that the perceived personal value girls give to science and mathematics is much lower than that of boys. The researchers also find a high correlation between perceived personal usefulness and performance in science and mathematics (Parsons, 1981, Pelgrum & Plomp, 1986).

Within science the interests of girls and boys are diverse. At the age of thirteen girls are more interested in features like the human body, the weather, colors and music. The boys' attention is mainly directed towards teh technical and spatial aspects of science (Johnson, 1984, Jörg, 1985)

Jörg (1985) asked 15/16 year old pupils, that already had chosen physics, which aspects should be given more attention within physics education. The results are shown in table 1.

Table [illegible].: Fields of interest to which boys and girls think more attention should be given in fourth from HAVO. (Jörg, 1985)

preference for	boys(N=146)	girls(N=40)
technical matters	67%	21%
nature	27%	38%
society	36%	49%
matters relating to the human body	14%	33%

The most marked difference is the greater interest of boys in technical matters. Jörg concludes after an experiment with a new physics curriculum that "girls seems to appreciate particulary those units that are concerned mainly with natural phenomena, the relation between physics and society or the meaning of physics for human beings and their wellbeing (e.g. 'Wheather changes','Electronics' and 'Ionizing Radiation'). The preference of boys is not so marked: they like units with a more technical content (e.g. 'Electrical Machinery') just as much." (Jörg, 1985,p.92).

The English research (HMI, 1980) located aspects of science education that especially girls did and did not like. Girls liked:
-to explore how things function, to create themselves things (they do have a certain amount of technical curiosity)
-doing practical work, simple experiments and undertake little research projects
-applications in industry and every day live
Girls did not like:
-the mathematical side, formulars and equations
-theoretical parts without sufficient practical support

usefulness for society

If it is clear for girls what the use is of what they have to learn, it stimulates them greatly. One way to stress the importance of the usefulness of science is to embed science education in the context of a societal problem. This often takes shape as an interdisciplinary project around a theme, e.g. energy problems in developing countries or the problem of noise annoyance. One can illustrate and explain all kind of physical, chemical and mathematical issues in the context of such a theme. Such projects raise the interests and motivation of girls (and boys too) for science and mathematics and their applications.

epilogue

It is clear that the interests of the broader group of girls is not directed towards pure technological aspects of science. It is not true either that girls have no interest at all in technological aspects. Some of the above mentioned research projects have shown that girls are interested in technology, however, only if it has a social or human impact. Boys are much more interested in technology for reasons of technology itself. They are much more interested in the achievements of technology in terms of power and speed.
Most authors explain the fact that so very few girls choose science major in secondary school has to do with the with the fact that the current science curricula does not link on the interests of girls. This probably also is one of the main causes of the shortage of women in engineering education.

IMAGES OF ENGINEERING EDUCATION AT SECONDARY SCHOOL

In the previous section is shown that at secondary schooling the 'distance' to technology is in general much greater for girls then for boys at the age of thirteen, which resulted in a very vague image from technology. (Raat and De Vries, 1986). Also at later ages the gender difference are found. Weerdenburg (cited in Schouten, 1987) has tried to measure the interests in technology with indicators like reading technical periodicals, looking at technical oriented TV-programs, technical hobbies,etc. He concluded that in general girls have much less interest in technological issues. However, this difference is not absolute: a specific group of girls (with science major) has equal or more interest than a specific group of boys (humanities equal). Now, it is interesting to focus on the group of girls with science major, as the group of potential engineering students.

Images and interest among girls with science major

At the Twente University of Technology a preliminary research has been conducted at the image of some fields of engineering among 16-17 year old female pupils with science major. These girls have attended a special information day on engineering education organized by the three technical universities in the Netherlands. A written questionaire about the interest

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in different fields of engineering and the arguments was send back by 121 girls (60%). Next to a written questionaire also some interviews were held with a smaller group of girls and boys. Since this group was rather small (N=21) conclusions can only be tentative, but in combination with other research the results can be directive.

One of the most striking gender differences in motivation for engineering education that came out of the interviews which is also supported by other findings, is that girls much often use 'intrinsic' motivations like, an interesting content, and doing something useful for people, while the boys more often use arguments concerning their own future career, like job possibilities and financial future. This is also found by Kvande (1985) and Gardner (1976).
Girls more often considered the biomedical side, most girls explicitily mentioned they enjoyed to create something tangible; engineering is not only thinking and theory [2]. However, half of the girls also mentioned that they found certain directions in engineering too limited, too technical.

Results from the written questionaire showed that especially Electrical Engineering, Informatics and Applied Mathematics were relatively often marked as dull, one-sided and too specialized, compared to the other directions offered at the Twente University (Technical Physics, Mechanical Engineering, Chemical Engineering and Technical Manegement). Electronics and Technical Physics were percieved as the most difficult and heavy studies.

tabel 1: interest of girls in different field af engineering education after participating at a special information day for girls only. percentages (N=121)

field	interested	not or less interested
electronics	33%	67%
informatics	35%	65%
mechanical engineering	44%	56%
chemical engineering	50%	50%
Technical Physics	54%	46%
Applied Mathematics	15%	85%
Management	50%	50%

Compared to the actual participation in the different fields of engineering, especially the fields which have no relation with secondary school knowlegde seems to benefit from the information days for secondary school girls, since Electronics and Mechanical Engineering also got many positive comments like, interesting and useful. The strong negative result concerning Applied Mathematics probably has to do with an uninteresting project during the information day.
68 out of the 121 respondents had the opinion that the information days changed their attitude towards engineering education positively.

EXPERIENCES OF WOMEN STUDYING TECHNOLOGY

In this part, the question is posed, whether also among the even more restricted group of female engineering students, the above mentioned tendency that girls and women have more feeling for the human and societal impacts of technolgy, can be observed.
Several studies show for female students in technology "being helpfull to others" and "doing something useful for society" are important motives for studying technology, more than for male students in general (Gardner, 1976, Kvande, 1985). Gardner, however, finds that after one year the item of being helpful to others strongly declined in importance for the female students. He concluded more general that "women have adopted the attitudes of the majority of their male peers within one year".
Gardner also finds that in a two year period the men and women equal transfer to another field of study of drop out. However, the reasons are quite different: the attrition rate for men caused by academic performance is five times as great as that for women. Women transferred more often because they felt restricted by the curriculum and the atmosphere of the university.
Kvande (1985) asked students in engineering which aspects they wanted to see more elaborated in the curriculum:

Table : Areas of study which should be allocated more weight in the syllabi. (Kvande, [illegible], p.224)

areas	female students	male students
social science	44%	31%
the engineers social responsibility	74%	55%
environmental subjects	51%	38%

Concrete experiences from female student at the Twente University

Results of research we have conducted among female students at the Twente University of Technology fits in nicely into the above mentioned results. We have only been interviewing female students so gender comparisons cannot be made. We held thirteen in-depht interviews with female students at the Twente University of Technology about their study career. We focused both on the social and the cognitive aspects, and their interwoveness. In the context of this article the results concerning attitudes towards societal and human impact of technology and the implications of these attitude for the choices made during the study will be emphasized.[3]

There are clear indications that most of the women we interviewed do indeed feel a responsibility for society and have strong human interests. This can be gathered from the way they have experienced different activities. 'Usefulness to society' was the one positive qualification most often mentioned when women evaluated the different activities they had pursued.

Three of the six women that did not finish their engineering study, stopped it not for academic reasons, but felt that the responsibility towards society and their criticism on the functioning of technology in society, conflicted with their engineering study. One of these women had become active in a student's Christian group where technology was often criticized for it's negative impacts on society. She could not see how she could put the mathemathics that she studied in service of society. This woman finally decided to stop her study and to attend a school for practical social work. Another woman of these three, who studies Informatics, tried to arrange on her own initiative a special interdisciplinary study program around the thema the use of informatics in environmental problems. She found informatics only too restrictive. She could not get support for this idea and finally decided to stop her study in informatics.

But also among the seven women that finished their study a strong societal commitment was present and had strong implications for the choices they made during their study.

Two women switched from a more technical field (electronics and chemical engineering) to management because this did not want to restrict themselves to technology only, they liked work with a more diverse character.

Two women who graduated in the field of applied mathematics did their doctoral thesis on a non technical subject. One applied mathematical models in sociology and the other in the field of educational science. They both found it very interesting to acquire knowledge in this field.

One woman (technical physics) graduated on a project on the economy of energy in houses. She is nowadays working on the increase of the efficiency of wood-burned ovens for developing countries.

From the two women who did chemical engineering one chose the biochemical direction and the other is worth a special story: This woman was a student-assistant at the Department of Philosophy. There she, too, was confronted with the negative consequences that technology can have for society, like pollution, alienation, etc.

> "I was confronted with all kinds of questions about the implications of technology. All this polluting technology, did I have to work on that too? I was rather pessimistic. At that time, I was making up my mind what to do after I got my bachelor's exam. Finally I decided to study Anthropology".

However, thanks to a university study-group on appropriate technologies for developing countries, she found a way to fit her interest in humanity within her chemistry study. She ended up doing her doctoral-thesis on the problem of water-purification in third world countries where she had to struggle with her tutors to get in non-technical aspects, like the implications of the introduction of new technolgies in the third world countries for the position of women.

This last example shows that it is, in fact, possible to integrate a strong feeling of social responsibility within the technology study. We can conclude that all the women we interviewed chose for socially relevant technologies. None of them chose a purely technological subject which main aim it is to enlarge our technological knowledge.

CONCLUSIONS

We can see that all groups of women mentioned above, from 8 years old girls to the female engineering students, have different attitudes towards technology and different interesest then their male peer group. The group of women who choose to study engineering is very restricted and even in this group a special emphasize on the societal and human aspects of technolgy. What's interesting about these findings however, is that these women were also able to integrate that desire at least into the later stages of their university study. This seems to indicate once more that the dry, technical picture of technology which one often encounters at secondary school is only part of the technology story. This also indicates that a more integral interdisciplinary approach in engineering education most probably has a positive impact on the participation of women in engineering education since it meets the more diverse interests of women.

Not only the fact that more women will enter engineering is important, but also the fact that the masculine character of engineering will change, will get more human, if more people with interests in societal and human aspects will work in engineering.

A last important remark is that girls and women in general do have less practical experience with technology. However, there sure is a latent interest in technology which can be deduced by the great interests women show for special courses for women in technology. Chivers (1983) also noticed this phenomena and concludes there is a "reluctance of girls to compete with boys in science and technology". Special courses only for women and girls will be necessary to give women the oppertunity to catch up their arrearage.

NOTES

1. It is interesting to know that the opinions of boys concerning the equal capacities of boys and girls strongly lag behind by the opinion af girls. Relatively much more boys believe girls are lesser able in mathematics and science. Cf. Fennema & Sherman (1977) and Smail & Kelly (1984).

2. This probably has to do with the fact that during the information days the girls participated in small product-oriented projects, whereas the boys only got information materials.

3. see for more detailled information Everts and Van Oost (1986)

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BETWEEN PROFESSIONAL COMMITMENT AND STATUS CONTINGENCY

Problems of stabilizing women's work in technical fields

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Abstract: Young qualified women workers in a technical field are torn between a) traditional measures of women's capacity for work as represented by their less skilled female co-workers, b) professional commitment and pride in their skills (which also extends to their private lifes) and c) conventional approaches to partnership. The ambiguities and constraints that result from these contradictions threat these women's position in relation to the female and male work roles within a firm, their ability to seize opportunities as well as their self-confidence. Attempts at improving the women's situation must give priority to number balancing and status stabilizing strategies. These are prerequisites for organizational changes in favour of women.

Introduction

Despite of multiple effort to attract more young women into science and technology there has been no real "take off" of women into engineering or skilled craft work in most European countries. The few who succeed in building up a career still find themselves in token positions. Young women who have mastered initial barriers and have developed a genuine interest in technical fields as well as self-confidence and ambition have difficulties to maintain their qualifications once they enter the labour market. It appears that although feminine values and orientations explain women's ambivalences toward achievement in men-dominated work organizations, their analysis does not provide sufficient insight into the problems of stabilizing women's work in technical fields.

Using the experiences of skilled women workers in Austria's metal industry, the following explanatory model is suggested:

- Employers' willingness to recruit women into skilled, engineering or managerial positions largely depends on whether the women set all those signals that make them recognizable as 'fully equivalent' workers: availability, willingness to invest into further training, high-wage orientation. Whether women are able to act like men is determined by their position in the reproduction process.

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- When women's jobs carry as much opportunity as men's in terms of learning and access to power, women do not exhibit specific gender-related strategies and work orientations; e.g. "jobs make people".
- Problems of stabilizing women's work in technical fields arise whereever traditional images of women's limited capacity for work are backed up by large numbers of women who are prepared to act as cheap and docile labour and are willing to cope with high levels of stress. Norms of female labour, incorporated for example in "the assembly-line worker" or in "the laboratory-assistant", depreciate the professional commitment and expertise of skilled women workers.
- Limited opportunity in turn strengthens the ambivalences and concerns that are part of women's stronger rootedness in family life.

"Femininity" in this model is not considered a prime source of discrimination; nor does the content of work "per se" alienate women from technical occupations. Prevailing social definitions of men's and women's work (in the factory as wéll as in the home) pose the perpetual threat to women engineers' or craft workers' opportunities to develop a career.

Big numbers vs tokens

The small group of Austrian metal workers considered in this paper have certified through exceptional effort and achievement as skilled workers and found appropriate employment. They have developed pride in their skills and identify strongly with craft work. They perceive the handling and shaping of "hard" materials and the analytical thinking required by assembling and testing electronic devices as providing deep sensual and intellectual pleasure. They have developed high standards of precision and efficiency:

> "I need the smell of metal. I love to see how a piece of metal develops into something."
>
> "So that every bit moves in one piece, that there is no movement that needs more time because it is not in tune ... Then I work until it fits."

Routinization and control of the production process, however, do not allow much room for refined skills and the harmony of movement. This is particularly felt when there is not enough skilled work available on the shop floor. The uneven demand for skilled work is one of the factors which reinforces traditional lines of division between men's work and women's work in the factory. While male skilled workers are used for heavy assembly-work and, temporarily, also for office work or in the ordnance stores, their equally qualified female colleagues are more likely to be assigned tasks that either require special manual dexterity and/or the production of high piece rates. One young electromechanic who supervised the winding of coils as her first job (and did the more difficult pieces herself) comments on these gender-specific work assignments:

> "Of men they believe, they don't have the skills, the patience ... A man can't do this type of work, women got more feeling."

One of her colleagues describes her superior's image of a skilled woman worker:

> "I have to do everything 135 percent - the (unskilled) women have a week or so to adjust themselves to a new job. Because I am skilled I have to be better, more dexterous with my fingers. He likes it best when I am as fast as them. For every single bit of waste they produce I should have extra quality."

Skilled women workers are in many subtle and less subtle ways compared to what women in industry "normally" do. The big numbers of unskilled women workers on the assembly line constitute the norm against which the abilities and aptitudes of the few tokens are measured. The example of a few pioneer women with a trained technical mind does not alter the historically grown image of typical women's work (which of course varies from industry to industry according to what kind of work has to be labelled as "typically feminine"). Many of the skilled women prefer dirty and heavy work (because it is better paid) to what superiors think of as more suitable for them. They tend to suffer more from what women are supposed to endure better - monotony, lack of intellectual demands, restriction of free movement - than from 'the hardships of male factory work'.

Depreciating notions of women's work together with the experience "some of those who did not have your training do better work than you!" soon overshadow the young skilled workers' initial self-confidence and thrive. Many of them behave as if they were locked into low position dead-end jobs. They seek to avoid risks and feel too insecure to push for promotion and more interesting work. This in turn reinforces widespread prejudices concerning women's general unwillingness to seize opportunities.

Much of the observed timidity and passivity of women working in technical fields can be explained as the result of such a depreciating process during the course of which already conquered domains - positions, qualifications - are continually threatened. Women engineers' or skilled craft workers' performance and career orientation appears to be a function of the relative distance of their actual work tasks from two points of reference:

+ from the dominant social reality of female work roles in an industry on one side,
+ from the privileged areas of highly specialized and often supervisory men's work on the other side.

It is remarkable how changes of job assignments affect the young metal workers' performance and their whole outlook on the job. The installation of a large electrical system on a construction site belongs to the more prestigious and particularly well paid jobs. There is very little "typically feminine" behaviour left in those among the young women who get a chance to do the real skilled jobs:

> " We were dusty, dirty - all of us - but I liked it, even though it was not nice work. I felt totally accepted. I belonged to them! I did the same work!"

Sadly enough, the necessity to be pereived as different from the unskilled women workers in the factory also weakens the basis for solidarity. Conflicts between women workers became frequent whenever the higher qualified women experienced the instability of their position and felt compelled to ascertain their expertise in order not to be put into the same category as the unlearned women:

> " One of them told me: Nonsense, why do you need all that (training)? I don't know why she said that. Maybe she is angry because she has to stand upright while working and I can sit..."

And another typical conflict:

> "... and she: What I am not your 'Kasperl'! I don't run around,in between! And I said: The boss said that I should stay where I am now. And she got really worked up and ran away."

Tensions seem to disappear as soon as the skilled women workers have accepted underqualified work assignments and start perceiving themselves as part of the disadvantaged work culture within the firm. Lack of solidarity is mainly a function of lack of opportunity and not of a presupposed "natural" competitiveness of women against each other.

Trained insecurity

Experiences of instability and depreciation affect the women's confidence in their own technical mind. It appears that private life and factory life often convey different messages. Being technically competent is so exceptional that it becomes a central part of the young women's personality. It contributes to their struggle for recognition among peers and in the family. Many young women have entered the privileged areas of male hobbies and leisure time activities, including the tending of prestige objects like motorbikes or Hifi equipment. They enjoy being able to join in 'expert talk' on technical issues. Frequently they take over the traditional male tasks in the home:

> "I could not imagine that my father would come to me and ask: 'How do you do that?' He always was a number too big for me. And now he asks me! This is just wonderful!"

Such experiences provide much support in everyday life, but they do not necessarily continue in work life. At work many young women hesitate to claim technical competence for themselves:

> "Technical knowledge - you see, is something more quailified. For this, I gather, women are less well suited."

This insecurity in assessing their own mind reflects on the one hand perceived differences between a (male) engineer's work and the tasks of a skilled metal worker. It at the same time reveals doubts concerning the value of their own technical competence. It is fairly common that young and inexperienced skilled workers lack some of the vast knowledge of materials and processes older unskilled workers have acquired over many years of on the job experience. For young women workers, however, this creates special tensions. They often find it difficult to ascertain their professional knowledge vis à vis older women with long production experience. Older male colleagues are perceived as models - the ones who possess the superior knowledge and who are good at explaining things. But the skills and critical remarks of the older unlearned women form the main point of reference for assessing their own qualifications.As if their gender-related affinity to the female work culture in the factory also determined the status of their professional knowledge!

This insecurity appears to be mainly a function of work experiences - a trained lack of self-assertion - rather than a general feature of the young women's education for femininity.

Traditional notions of partnership

Being a skilled woman worker or a woman engineer does not fit into conventional approaches to partnership and motherhood. This affects the young women's career planning. Many of them want to have children. Although they aim at sharing the household chores with their partners, they still think of childcare as being their sole responsibility. A non-traditional occupational choice does not necessarily imply non-traditional notions of family life. This is visible in their choice of partners. The men they find attractive (and that are available) are usually not willing to invest more time in family life.

Thus built into many young women's professional commitment is the idea of having to give up one day what forms a central part of their self-esteem and personality:

> "I prefer lying under a car, to fix this and that. This is what my job gives me. Because I love my work, more than anything else. But this will hopefully change - it has to change!"

This splitting-up - ofworking in an unusual profession and of having to conform to traditional notions of motherhood - plays a central role in actual conflicts at work. Whenever the career seems to be threatened many young women make a radical shift to the family side of their personality: they want to have a child 'at once'. Success at work on the other hand reinforces the idea of postponing motherhood 'until I am at least thirty'.

Given this basic conflict, many young women tend to interpret their professional work in terms of conventional notions of femininity:

> "When I have children, I can't be a mechanic, can I ? I have no hand for babies. Such clumsy hands and so dirty. God knows how I will speak ...".

In this (certainly extreme) example a young mechanic measures herself against a norm of female sensitivity - she thinks to fail. This points to a basic dilemma of women in technical fields. The very same qualities which mean recognition and success at work seem to devalue their femininity. Enthusiasm for cars as well as'clumsy hands'are perceived as risks of social acceptance. Most young women have difficulties to relate both spheres - the home and work - to each other in terms of roles, values and behaviour. This perceived unrelatedness nourrishes fears of becoming 'unwomanly'.

Conclusions

The working conditions of qualified women in technical fields are highly unstable. Comparison with a norm of female work makes it difficult for these women to maintain their professional commitment and widen their knowledge on the labour market. The oscillation between female and male (work) roles affects the women's trust in their own technical competence and their ability to seize opportunities. It impedes the social construction of a positive image of women working in technical fields.

This conflict between individual women's commitment to a technical career and the pressures and constraints of an unstable in-between position cannot be solved by improving schooling and vocational training. They have to be tackled directly on the external and internal labour market.

A more equal representation of women and men on all levels of the occupational hierarchy within a firm (secretaries, laboratory-assistants, craft workers, engineers, managers) seems to be vital if traditional images of women's work are to be replaced. This number balancing strategy is a prerequisite for all other organization-centered action in favour of women to succeed (opportunity-enhancing efforts, empowering strategies, Kanter 1977). Before women can make efficient use of such organizational change like job rotation, decentralization and flattening of the hierarchy, explicit measures have to be taken that prevent the trapping of technically competent women in a self-defeating circle of underemployment and lowered aspirations.

The status inconsistencies described in this paper have to be avoided from the very beginning of a woman's entrance into a technical field.

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WOMEN AND HIGHER EDUCATION IN COMPUTER SCIENCE IN THE NORDIC COUNTRIES

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Presentation of a Research Project

1. INTRODUCTION

This study aims to obtain information about the requirements for getting more women to participate in higher education in computer science in the various Nordic countries. We shall focus on the factors which are important in *attracting* women to this type of education. This approach is an alternative to the more traditional one, which focuses on the reasons why women do *not* take this type of education. It will be valuable to disclose positive factors when the strategy is aimed at increasing the proportion of women in higher education in computer science.

The idea for this project came from a Nordic conference "Nordic Meeting on Equality of the Sexes in Computer Science", held in Oslo in 1985. In the summing up at this conference there was a request for research on a Nordic level which could lead to information about work on recruitment and equality being spread more effectively and faster.

2. BACKGROUND

A common trait for the situation of women in computer science in the Nordic countries is that women are predominant at the bottom of the heirarchies. At the lowest levels, e.g. registration of data, we find almost 100% women, while in management positions we only find 5-10% women. The same tendency applies to the education system: women are best represented on the shortest courses and worst on the longest ones. In the Swedish one-year course for programmers we find 55% women, while the four-year course for computer engineers has only 10% women. The same tendency is also apparent in the other Nordic countries.

A preliminary check through the available statistics suggests that there is an increasing proportion of women in the shortest and medium-length courses, but a stagnating and perhaps decreasing proportion of women in longer courses. This represents the opposite tendency to that which is seen for women's representation in higher technological courses in general. In all the Nordic countries an increase can be registered here. At the Norwegian Institute of Technology (NTH), for example, there has been a general increase from 7% to 30% in five years, yet the proportion of women in the Division of Computer Science is now 15.8%.

Although the figures are uncertain, the tendency towards stagnation is clear enough and it is a development which is common to the Nordic countries. The stagnation of female representation in advanced computer science is unfortunate when these very countries have traditionally been in the forefront as far as equality of the sexes is concerned.

The ideal of equality has been central to the education policies of all the Nordic countries since the war. The aim has been to give everyone the same opportunity for education, regardless of sex or social and geographical background. Women's education has on average reached a lower level than men's and this has been considered one of the obstacles to greater equality between men and women. It has also been the background for the fact that policies on equality in the Nordic countries have concentrated on education as an important means of achieving equality.

Education is also considered important in the increased stress on technology in general and information technology in particular. In this connection too, women are seen as an unexploited potential. In public reports there are requests for measures to be taken to increase recruitment of the latent reserve which women represent.

In addition to the argument for a better use of the potential represented by women, researchers have also pointed out the importance to society of women receiving technological education (Stauning 1984, Zimmerman 1981, Rotschield 1981). Advanced technological education represents potential for influence, which it is important that women should also have. One reason for this is that women perhaps represent special interests which need to.be looked after in the process of technological development (Hein 1981). The tendency on the labour market is towards a wider gulf between technically qualified and unskilled workers, so that women's traditionally weak position can become worse if they do not have technical knowledge. The aim has been stated that women and men should have more equal chances of participation and influence in the various spheres of society.

As a part of the increased interest in women in technological work and education several research projects have been started in the Nordic countries. In Sweden Ingrid Granstam (1981 and 1982) looked at the various aspects of recruitment to the University of Technology in Linkøping, and the Swedish Society of Graduate Engineers (Civilingeniør- forbundet) completed a survey on working conditions for female graduate engineers. Yvonne Due Billing and Anne Bruvik Hansen (1984) carried out an extensive survey on recruitment to science subjects in

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upper secondary schools and in the universities of technology. In Finland Carita Peltonen and Solveig Bergman (1985) completed a similar project. Perhaps Norway has put most effort into increasing the number of women in higher technological education and this has led to the increase already mentioned. In connection with this the research project "Women and Advanced Technological Education" was carried out (Kvande, 1982 and 1984).

These studies reveal several similarities between the Nordic countries which are worth considering more closely. However, these projects concentrated on the representation of women at colleges of advanced technology and universities, in other words the courses leading to qualification as graduate engineers. The results are therefore not applicable to higher education in computer science in general, as such courses are also offered at a number of other colleges and universities.

This also leads to an interesting field of research: by looking more closely at the differences between the various colleges and universities and between the Nordic countries we can discover the main variables. In Denmark, for example, we find great variations. In Århus and Aalborg where there is a strong connection with mathematics and physics there is a small proportion of women (approx. 10%), while in Roskilde where datalogy is studied as an arts subject, the proportion of women is as much as approx. 35%. Thus it appears that this proportion can be increased by gearing higher education in computer science to the humanities. This in its turn must be seen in connection with the discussion about the importance of the content and teaching of the subjects (cf. New Scientist, February 1986). Sjøberg and Lie (1983) showed that girls are more interested in physics as a subject when it is presented in the context of society. In the project about women and higher technological education we also found that female students preferred subjects which could be seen in relation to society. This is also the background for the fact that several of the Nordic countries now have working groups looking at the content and teaching of computer studies.

3. RESEARCH TOPICS

The project aims to contribute to further knowledge of the requirements for increasing the proportion of women in higher education in computer science in the Nordic countries. It has been usual to approach this by referring to sexual roles in order to explain women's lack of participation in important fields. The concept of sexual roles has many facets and is often not concrete enough to form a starting point for change. Therefore we shall use another angle of approach in our analysis. We shall start with the institutional requirements, by which we mean both concrete measures which attract women to this type of education and also the content and teaching of computer studies. This approach is geared to action by being more suited for identifying the more short term possibilities than a change of sexual roles would do.

The reason for comparing the Nordic countries in this survey is that positive experiences of successful measures tried in one country can thus be made available to the others. Increased concentration on information technology and a well defined profile of equal status for women are two important political areas which are common to all the Nordic countries. However there are some real differences between the countries in practice. Finland, for example, has a greater proportion of women in this type of education than the other countries. This may mean that the various countries make different connections between concentration on information technology and the goal of equal status. As the two central themes, information technology and equal status, are common to all the Nordic countries, it is the

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differences in the way measures are planned that are interesting and worth passing on.

We shall concentrate the survey on three central questions:

1) What is the actual proportion of women in higher education in computer science in the Nordic countries?

Although the general tendency in the Nordic countries is one of stagnation, there are a number of interesting variations. The statistics available at present show for example that in Finland about 30% of the students in higher education in computer science are women. At the moment there are few systematic statistics available to throw light on these variations. Much of the statistics consists of approximate figures. In Denmark, for example, the female representation in higher education in computer science is estimated to be 5 - 15%. In other words the available statistics ought to be reattained and systemized considerably, not least in order to provide comparable figures on a Nordic basis. (cf. Recommendation of the committee for increasing the female representation in the Department of Information Studies, 1985)

2) Which measures have been planned or carried out in order to increase the proportion of women?

Here we are concerned with measures initiated or undertaken by public authorities within politics and planning. In addition we shall consider measures taken by the various colleges and universities. For the reasons already given, we shall lay special emphasis on the institutions which have completed successful measures. In addition to the measures which are of a formal nature it will be important to include the more informal measures which the students themselves have initiated. Here we shall also evaluate the measures used to increase the proportion of women at the various colleges and universities. We shall emphasize in particular any measures which can profitably be taken over by the other Nordic countries.

3) How important to women who are considering applying for a course in computer science is the content and structure of the course?

Here we shall consider more systematically the experience gained from the various types of course. As we mentioned above, other research results indicate that this has an important bearing on female representation in technical and scientific subjects. By surveying this and making comparisons on a Nordic basis, it will be possible to include so many units that the importance of the different types of course will be easier to evaluate.

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GIRLS AND MATHEMATICS: SUMMARY OF OUR RECENT FINDINGS

GIRLS AND MATHEMATICS RESEARCH UNIT

UNIVERSITY OF LONDON INSTITUTE OF EDUCATION

The Girls and Mathematics Unit is the only one of its kind in Great Britain. Established in 1978, it has since undertaken the largest amount of funded research in this area in Europe.

This paper is a summary of a selection of the findings from a number of studies carried out by the Girls and Mathematics Unit.

The Data

1. An observational study of 30 four year-old girls stratified by social class (15 working class, 15 middle class). These girls were observed at home with their mother and at Nursery School.
2. An ethnographic study of two nursery schools examining aspects of stereotyping and gendered play.
3. A detailed study of one Infant School examining the performance of six year-old girls in test data, observation, interviews of girls, teachers and parents, and observations at home.
4. A follow-up study of the four year-olds at the age of ten, with interviews and test data on the performance of children in 26 primary schools.
5. A study of girls and boys in two primary schools and their transition into mixed classes of the first year of a comprehensive school. Data includes observation, testing of all pupils, repertory grids and interviews with children and teachers.
6. A study of pupils in the IVth year of the same comprehensive school. Data includes observation, testing and interviews.

Findings

As is obvious from studies of this magnitude the resulting data analysis is both very detailed and extremely complex. This appears in a number of publications (Walden and Walkerdine, 1982; Walden and Walkerdine, 1985; Walkerdine, Lucey and Watson, 1986; Walkerdine, Lucey and Watson, in press; Walkerdine (ed) in press; as well as a number of journal articles). In this paper we will simply summarize some of the findings which are generalizable across the age range and samples.

One of the major conclusions from our research is that contrary to popular opinion girls from four to fifteen when compared with boys are not performing poorly in mathematics. Our earlier studies had demonstrated the good performance of girls up until the end of primary school. We had been led to expect a decline in the performance in secondary schools. In Britain, unlike the USA, children cannot 'opt out' of mathematics below the age of sixteen. The expected decline in performance was totally absent in our data. However this did not mean that there were no problems for girls. We found that girls were massively discriminated against and were having a very difficult time. This led us to examine the relationship between ideology and performance.

Throughout the data, and throughout the age-range, the differences in performance between girls and boys are far outweighed by a 'self-fulfilling prophecy' effect in which teacher attributions of the cause of good and poor performance are strongly gender-differentiated. While boys' performance is often described in terms which stress potential and possession of 'brains' and understanding, (even when this performance is poor) it is, by contrast, rare for girls to be described in these terms and their performance, no matter how good, is commonly attributed to 'hard work'.

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For example, it was often the case for teachers to refer to good children using such terms as 'competent'; 'capable'; able to 'pick up' and understand concepts quickly. Accuracy, speed and what is described as 'intelligent' application of prior mathematical knowledge was also mentioned. However categories which referred to the intellect and to the 'ability' rather than attainment were used in a gender and class specific way. Of the sample we studied, the number of boys and girls ranked in the top 5 of their learning groups did not differ significantly, but the terms used to describe them did. In middle class schools, concepts such as 'ability', 'bright' and 'intellectual capacity' were attributed with significantly greater frequency to boys than girls - the exception being a private all girls' school where almost all the pupils were attributed with natural ability. In assessing performance they took to be equivalent teachers in middle class schools tended to relate girls' success to sheer hard work rather than 'flair'. Hard work is frequently seen as a contrastive opposition to 'bright' as in the following quotation:

> 'Very, very hard worker. Not a particularly bright girl ...
> her hard work gets her to her standard'.

These differences in attribution are important for several reasons. Firstly it is common both with educational discourses and early mathematical education to contrast the old ways of hard work and following rules with the new concepts of development, activity and so forth (Walkerdine, 1984; Walden and Walkerdine, 1985). Secondly it suggests that any child who is seen to be working must be lacking 'ability or flair'; intellect is thus assumed to be inherent and therefore invisible in terms of effort. Thirdly, variants of these distinctions are ubiquitous ranging from infant to secondary school.

What becomes paramount, is that these concepts are taken up and used accordingly in working class and middle class schools. In working class schools, whilst some teachers devalued girls' hard work and effort, the

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majority viewed it positively. However, even here, 'hard work' was applied to few boys. This phenomenon is important in understanding the 'relative' success of some working class girls.

Another term applied to girls is 'mature': well behaved, settle down, work quickly and quietly. However, it can be pejorative in the sense that it can, like 'hard work' be used to 'explain away' good performance. Whereas in boys, both high and low achievers, 'late development' and maturity are explanations of their peer performances (and an ability which, indeed, remains, as yet, hidden). By comparison all working class poor girls were characterized as unconfident and lacking in ability.

Teachers' judgements of boys largely saw them as potentially bright. Poor boys were often characterized by disruptive and sometimes violent behaviour in class, and as lazy and sullen. Yet they are taken to possess an inherent 'brightness':

> 'He's the one that went into a sulk ... he can't be told anything, you can't even get places. But I'm pleased with the way he gets on. He's quite bright.'
>
> '... can just about write his own name ... not because he's not clever, because he's not capable, but he just can't sit still, he's got no concentration .. very disruptive .. but quite bright.'

This seems to imply that boys display behaviour problems which are actually taken on board by the teacher who expects to deal positively with this without feeling threatened - because the boy has ability!!

Home circumstances were used in a similar way. That is, girls' home lives were often presented as information and they were positioned as coping well in difficult circumstances, whereas boys' family circumstances or history was used as an explanation of poor performance.

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This is important because it is simply not the case there there is an overarching failure of girls per se. The failure of girls to enter the professions requiring mathematics must be explained in other ways. In our research, girls were performing well (and in some cases, out-performing boys) even up to the fourth year of the secondary school.

However, because of the categorization of girls' performance, they were discriminated against when it came to examination entry. Girls were held back because they were felt to be less confident. Part of the secondary school analysis focused on specifically school based curriculum materials and its use as a mathematics scheme in the school. Interestingly, it appeared that girls did relatively well using this scheme which reflected similar material from primary school practice. The good girls were comfortable with the safety of the work which ultimately facilitated their relative success enavling the continuance of hard work together with 'feminine' and helpful behaviour. The good boys on the other hand baulked at the scheme finding it boring and wishing to break away from its constraining format.

By the IVth year girls were doing better than boys in maths and liked it better. Yet when it came to a question of examination entry, teachers tended to choose boys with 'flair' for 'O' level and hard-working girls for CSE despite their performance in the mock exam. It is in this way that we might begin to explain some aspects of the performance difference in 'O' level entry and successes. More girls are entered for CSE Maths both because of their 'lack of confidence' and because they are perceived as 'hard workers'. By the same token, they are not 'pushed'. This means that they are less likely to do as well as the boys.

In the classroom too, it was difficult for girls to display precisely that kind of interaction which counted as 'understanding' or 'brilliance'.

In brief, we found that not only did teachers validate 'flair' in boys by positively marking, extending and evaluating boys' challenges in class, but they resisted any display by girls of similar behaviour. That is, intellectual aggression and challenge by girls was blocked and deflected on every occasion that it was presented. Thus not only did girls strive to be compliant, but any attempt to produce that behaviour deemed necessary to mathematical understanding was thwarted by the teachers on every occasion that it occurred. Conversely teachers validated the participation of boys. This would seem to give support to the concern expressed elsewhere that girls would find it easier in maths if taught in single sex groups.

Furthermore, the challenges made by boys played into and extended into naughtiness and violence, of which the girls spoke much at all ages. And although teachers were the object of sexism, they often unwittingly validated it precisely because they linked naughtiness to challenge, considering it 'natural'.

At first we had looked at girls as a unitary category, but it became increasingly clear as our work progressed that there were substantive and important differences between girls. These were not in any simple sense due to performance, but these differences occurred between working class and middle class girls. We did not examine this in our study but suggest that racism may operate in similar ways.

Whilst it was made difficult for girls to challenge, differences in socialization practices in working and middle class homes were very important. Although earlier research stressed 'play' and stereotyping, we found it far more important that practices of domestic regulation led to differential 'styles' on the part of girls. It was simply not the case that a traditional gender role led to failure. In the data on the 4 and 10 year-olds we operationalized the contrastive pair big girls/babies which was most common in working class homes. Big girls helped their mother by being responsible

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and self-reliant. Their mother stressed their necessity to complete a large number of domestic chores within a specific time limit. This led to the practice of working class mothers' praising their daughter's independence, marking them as 'clever'. In contrast, babies are constantly demanding attention and to be looked after, and often revert to infantile behaviour.

This set of terms appears to produce certain affective/intellectual effects at 10. All the 'big girls' have become sub-teachers, are doing well at school, and are seen as responsible in the classroom. However, the fate of the babies is very distressing. They are seen as stupid and lacking ability by their teachers, which is in marked contrast to their designation as clever by their mothers. Neither in the nursery at four, nor at school at ten do the teachers of these children reward their steps towards independence or positively mark it. It appears importantly related therefore that these girls all see themselves as victims and display marked paranoid tendencies. In the clinical literature, such problems are associated with separation anxieties.

The middle class girls display none of these tendencies. The contrastive pair, big girl/baby is not used, but rather the terms, sensible/silly are more common and relate to intellectualization and reasoning. Intellectualization is expected and not praised, and indeed lack of intellectualization is marked as silly. Daughters of professional and middle class mothers were 'pushed' to intellectualize, and within this framework, housework either took on a central role in pedagogic discourse or it could be marginalized or displaced in order for more formal learning processes to take place.

Extending this further, we felt it important to elicit the differences which were emerging in the child rearing practices. We have already noted the Big Girl relationship with her mother, who is constrained by time, so she leaves her mother alone. Now within this context the mother then is positioned as *domestic*, but importantly it does not appear that these girls copy their mothers in a trivial sense of stereotyping of women's domestic work. Rather what seems to be occurring is that these girls are becoming reliable, responsible and efficient. It is not surprising therefore that the majority of the working class daughters at the age of ten display aspirations to join the caring professions. That is, they desire mobility in *class* terms, but not in terms of gender.

As previously stated, the majority of middle class mothers, do not *so obviously* engage in domestic tasks - it tends to be hidden and constantly interrupted in order to attend to the daughter's demands. They thus 'appear' more sensitive and their daughters more powerful, but this is illusory. Such differences must be related to ideologies of mothering and child-care (Urwin, 1985; Riley, 1983) and also to the varying socio-economic circumstances of the types of mother. In each case, the mothers appear to feel pressured, but the pressures to have the housework and so be respectable are quite different from pressures towards sensitivity and intellectualization.

Crucially the relationship we are trying to draw attention to, despite the complexity of the issue, is that between working class and middle class domestic and mothering practices and the positioning and attainment of the daughters, and their career aspirations. Within this context *none* of the middle class girls wanted to help people. They were far more open to 'masculine' careers. But until discourse on girls' aspirations appreciate the centrality of class, it cannot effectively engage with the issue of the take up of careers requiring mathematics and science. That is, working class girls aspire to *professions*, but ones which are extensions of the strengths they have acquired as *big girls*, responsible carers, 'helpers', sub-teachers. These are not intellectual but class aspirations. We would suggest that to expect such girls to choose middle class masculine professions, is to expect too much at this stage. Moreover it is precisely these girls who are regarded as 'rule followers' displaying procedural and not proportional knowledge. As we have seen from the teachers' judgements, such girls, no matter how well they do, are never really said to be properly knowledgeable.

Thus it simply cannot be suggested therefore that working class girls are more 'feminine'. It is more the case that the pressures on them push them towards the caring professions, and it would seem too much, to just expect such girls to transgress the boundaries of role expectation. Moreover it is often these girls who are deemed 'hard working' and therefore second rate.

Finally, to reiterate, we suggest that many existing accounts of gender differences in educational performance, although tapping into important issues - classroom interaction, socialisation, anxiety - often miss the point because they have not had access to the in-depth fine-grained detail supplied by the transcript based studies. We believe that our work has massive implications for practice, because Equal Opportunities programmes, no matter how well-intentioned, unless they take on board not just the dimension of gender, but also the cross-cutting discourses of class and femininity, remain pious and therefore although necessary are insufficient in themselves.

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GENDER AND COMPUTERS IN ENGLISH PRIMARY SCHOOLS

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There has been very little research on gender and computers in primary schools. Much of what exists is contradictory, suggesting the need for a lot more investigation. For instance, both Beeson (1985) and Harvey (1985) found few differences in boys' and girls' attitudes to or use of the computer. On the other hand, both Gribbin (1984) and Clarke (1985) have found such differences. All these studies concentrated on the attitudes and actions of the children. Our suggestion is that looking at these attitudes and actions, important though they are, will not tell the whole story. After all, girls show plenty of positive attitudes to maths and science in the primary school, but they turn away from them later on. The suggestion in this article is that a clue to the reasons can be found in the world picture that primary children are building up in their primary schools. This picture becomes part of their belief structure which will affect the choices they make later in the secondary school more than it affects their activities in the primary school.

In 1985 we carried out a survey of the primary schools in Kent with the aim of discovering the ways schools organized the use of microcomputers and whether there were any gender-related differences that might affect children's perception of them. We approached 182 headteachers, in a randomly selected third of the schools. 172 of them replied - a response rate of 94%. We tested the following hypotheses:

1)Men rather than women take responsibility for the microcomputers.

2) Microcomputers have become associated with the "boys' subjects" of maths and science.

3) Male heads are likely to be more involved and enthusiastic than female heads.

The results were extremely interesting, because the degree to which the hypotheses were upheld contains clues about the reasons that the present situation has evolved and so give us pointers to the directions of future developments. These clues depend on the distribution of men and women in schools, and the posts of responsibility that they hold there.

Primary heads are enthusiastic about micros. 84% of all schools had at least one computer, and this figure rises to 91% if infant schools are left out. The government contributes half the cost of the first computer, but about a third of the schools have more than one computer, and nearly half have enough for at least one between four classes. These figures should be seen in the light of the fact that both hardware and software are expensive, and schools are extremely short of money at the moment. The enthusiasm also appears in the heads' comments on our questionnaire. Just over half of them chose to write comments on the forms. Of these comments, nearly three quarters were positive about computers, and only a sixth of them were negative.

Gender differences in the teachers' use of computers have to be seen against the background of the proportions of men and women in schools. Women are in the majority overall, but they are less likely to be heads, particularly of schools for older children and of large schools. While most primary-school teachers (80%) are women, less than half (only 43%) of primary school heads are women. The proportion of women decreases as the children get older - and this is most marked for head teachers. Thus 91% of Infant-school teachers and 87% of Infant-school heads are women, but in Junior schools 76% of teachers and 18% of heads are women. In fact, in Junior schools nearly a third (28%) of the men on teaching staffs are heads. The proportion of women heads decreases as schools get larger. This is partly because older children tend to be in larger schools. But it is true independently of this factor: taking only the Junior-Infant schools, the proportion of women heads falls from 50% in small schools with less than 100 pupils to 20% in schools with between 100 and 250 pupils, rising slightly to 30% with above 250 pupils. (Significant at the 0.02 level using the Chi-square test.)

So far, the picture against which the hypotheses are to be tested is one of primary schools eager to use the computers in their teaching, (though hampered by lack of resources). These primary schools are mostly staffed by women, with the few men there being found disproportionately in headships.

Were the hypotheses upheld? Yes, and no, depending on how closely they are examined.

It is certainly true that men rather than women are taking responsibility for the microcomputers. If there were no bias, only 20% of those taking responsibility would be men, but of the 134 teachers taking responsibility for the computers about half (66) were men. Eighteen of them are the only man on the staff. (Significant at the .000 level - in fact off the scale of my Chi-squared tables.) The hypothesis remains upheld if junior schools are considered on their own, where of the 28 people taking responsibility for the computer, 17 (over half) are men, two of whom are the only men on the staff. This is still highly significant (.001 level).

It is also true that micros are associated with the "boys' subjects" of maths and science. We asked whether teachers taking responsibility for the micro also took responsibility for maths and/or science. We assume that all schools have somebody responsible for maths and science, but we are not sure how often the two are combined into one post of responsibility. Assuming the 63 schools are representative in this respect, (ie that they are not a biased sample of schools in choosing to combine maths with science or not,) the number of posts in 136 schools can be calculated. Using these figures, the significance of the association between computers and maths or science is at the same extremely high level as the association with men rather than women.

It is also true that male heads are more likely to be more enthusiastic and involved than female heads. Overall, the significance of the connection between the sex of the head and the school's having a computer is at the .001 level, and the significance of the connection between the sex of the head and the school's having more than one computer is at the .002 level. However, in spite of the strength of these connections, it is not true that the connection is caused by gender. It is a result of the proportion of male and female heads in different types of school and in different sizes of school. As we have already noted, women are far less likely to be heads in large schools for older children. If these factors of size and age-range of school are corrected for, there appear to be *no gender differences at all between the male and female heads*

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as far as computing in schools is concerned. Moreover, other indicators confirm this. The men and women heads are equally likely to own a home computer - about a quarter of them do. They are equally likely to take responsibility for the computer. (Again about a quarter of them do).

In short, the association which can easily be seen between the sex of the head and the use of microcomputers is very misleading. In any group of male or female heads there will be more men than women knowledgeable and involved with computers, but this is only because they are more likely to come from big schools with older children. Perhaps the same is true of the association already noted between teachers taking responsibility for the micro and the sex of the teacher?

If it were the sex of the teacher rather than their curriculum specialism that led them to take responsibility for computing, then men would take responsibility regardless of their subject specialism, women only if they were knowledgeable in areas usually assigned to men. However, the opposite is the case. Using the same assumptions as before about the numbers of maths and science posts in schools, it appears that while the association is very strong for both men and women, it is less strong in the case of the women than the men. Perhaps women associate computers more with language work and word processing? Or with environmental studies? The next part of the survey dealing with teachers' attitudes (yet to be analysed) will give us some of the answers.

There seems to be no special unwillingness among women to deal with computers, and, moreover, less association in their minds between microcomputing and maths and science. However, to discover this needs a knowledge of the proportion of men and women taking different roles at school. A casual observer is more likely to see computers in primary school as the domain of men. The software producers will be dealing disproportionately with men, and with those interested in maths and science. In primary schools the numbers of knowledgeable men will be greater than the numbers of knowledgeable women. Promotion and influence depending on this knowledge will more likely go to men. And, most importantly, the children in schools (and students in colleges) will be learning the lesson that computers are part of man's world. The process leading to computers being part of a man's world seems well established. The next generation of teachers is likely, therefore, to be less open-minded than the present one. They will have begun to internalize the stereotype which will in turn become correspondingly stronger. Luckily, there is nothing inevitable about the process. It is still possible for the education system to change its own part in it. A casual glance through the magazine.rack shows that educational computing is still much less male-biased than the rest of the computing world. It is a world that needs educating, and it is a world that needs women.

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THE SIGNIFICANCE OF SCHOOL AND OUT-OF-SCHOOL CONDITIONS IN THE DEVELOPMENT OF MALE AND FEMALE STUDENTS' INTEREST: THE EXAMPLE OF PHYSICS

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Introduction

From the point of view of educational theory, interest may be seen as the medium and the goal of educational processes (SCHIEFELE et al. 1978). A wide range of studies have repeatedly confirmed that students' interests in science, particularly in physics, systematically decrease in the course of secondary level I (i.e. grade 5 to 10; ages 10 to 16) and that girls are in general less interested in physics than boys are (GARDNER 1985). These data thus appear to indicate that the outcome of instruction is contrary to the goal, which is that interest should be present at the end of the learning process. A closer, more detailed examination reveals, however, that there is no general decrease in students' interests in physics. This is one of the results of a broad-based study on the development and change of students' interests in physics during secondary level I, which was commenced in 1984[1]. It combines a cross-sectional study of about 4,000 students with a longitudinal study of some 1,200 students from grade 5 to 10. Some of the results of the cross-sectional study are discussed below.

Dimensions of the construct 'interest in physics'

Drawing on a curricular model of physics education developed by HÄUSSLER et al. (1980, 1982) it is assumed that students' interest in physics may be broken down into three dimensions whereby each dimension is defined by several categories:

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[1] The study is being conducted by L. Hoffmann, M. Lehrke and P. Häussler, all research members of the Institute of Science Education (IPN) at the University of Kiel, in co-operation with Prof. E. Todt from the University of Giessen.

1) interest in a particular subject matter or topic of physics
2) interest in a particular context in which that topic is presented and
3) interest to engage in a particular activity in conjunction with that topic.

A test instrument was developed which comprised 88 items, each combining systematically one particular topic (out of eight), one particular context (out of seven) and one particular activity (out of four levels of activities). The structure of the context activity combination was kept constant for all topics so that the students' responses could be evaluated with specific reference to topic context and activity (cf. HÄUSSLER 1987). To facilitate classification of the results the students were also asked to indicate their interest in the individual topcis, contexts and activities. For this the number of topics and contexts was increased and the activities were specified (cf. HOFFMANN/LEHRKE 1986).

In addition to data on students' general interests in physics, students' interests in physics as a school subject in comparison with their interests in other school subjects, as well as the extent to which they occupy themselves with physics and technology during their leisure time were investigated.

Subjective conditions of students' interests in physics

We proceed from the assumption that the development and differentiation of interest structures are part of self-concept and ego development. According to DÖBERT et al. (1977), the process of self-concept and ego development is linked to cognitive development. They assume that the individual achieves, in a way which may be compared to PIAGET's (1947) stages of cognitive development, different stages of role-taking and changes in orientation of life according to the different developmental tasks with which he/she is confronted (cf. e.g. HAVIGHURST 1967). On the basis of the role-taking and the changing life orientations, the individual acquires increased interaction competence. We assume that in connection with this

the individual's value structure changes, which results in differentiation and specification of the interest structures, where the first channelling is a consequence of familial socialization (such as support from the father/mother, including the perceived model behavior, as well as the perceived extent of stimulation to activity and support given).
Besides parental support and individual out-of-school experience, the physics instruction with which the adolescent is confronted is, in our opinion, of particular significance in the formation of her/his physics interests. The contents, contexts and activities of instruction are contributing factors here, as well as the climate of instruction. A more detailed description of the design of the variables may be found in HOFFMANN et al. 1985.

Our study incorporated all these conditions, some in retrospective form through the students' subjective perception.

Comparison of expressed interest with frequency of inclusion in instruction

As early as the end of grade 5, i.e. before physics instruction has begun for most students, girls show significantly less interest than boys in most areas of physics. Exceptions are the topics acoustics, optics and atomic theory. The greatest discrepancy between the sexes is for electronics.
A distinct decrease in interest, more marked among girls than boys, can be observed in grade 7. Subsequent changes are relatively small. For most students physics instruction begins in grade 7. This change in interest does not apply to astrophysics, communication technology and radioactivity/nuclear energy. In these areas the interest of both male and female students remains almost constant.
The four areas of physics judged on average by the students as most interesting were astronomy, computers, aviation, and atomic theory (for girls)/electronics (for boys). These were joined in grade 10 by radioactivity/nuclear energy for the girls and communication technology for the boys. These topics however, are not taught in schools, or if at all then only in

grade 9 or 10.

The students' statements indicate that the contexts occuring most frequently in physics lessons were "Description and explanation of experiments, processes and phenomena in physics" and "Natural laws which allow us to calculate exactly specific quantities in physics". These occupy, however, a very low position in the rank order of the students' interests. In contrast, the contexts for which the students express high interest were relatively rare. For the girls these contexts are:
"Processes and phenomena which can be directly observed and experienced"
"Applications in medicine"
"The application of technological developments which can benefit us now and in the future"
"The application of technological developments which involve considerable risks to ourselves and to the environment".

There were similar results for students' interests in particular activities. Girls and boys expressed high interest in activities at the practical-constructive level, such as "Building something, setting up an experiment", "Conducting an experiment yourself; taking measurements", and "Testing something, taking a device apart or putting it together". From the end of grade 8 onwards, however, the activity "Watching experiments" is first on the girls scale of preference. Both male and female students indicate relatively low interest in activities at the theoretical-constructive level, such as "Reflecting how the validity of a supposition could be tested by an experiment" and "Calculating something predicting exactly the result of an experiment, solving problems".

The longitudinal study should prove useful in the investigation of whether, for example, the shift in the girls' interest from activities at the practical-constructive level before grade 8 to a more passive observation of experiments in grade 8 is due to negative experiences during physics instruction, and to what extent the discrepancy between the students' interest in particular contexts and activities on the one hand and their occurence in instruction on the other influences individual interest development.

The students' responses to the test provide us with detailed indications of how physics instruction could be adapted to suit the interests of girls. Specific examples include the following:

- Simple machines often serve as an introduction to mechanics, yet for girls this is not particularly interesting. An introduction to mechanics through the medium of, say, road safety would be interesting for both girls and boys. For boys an oil pump is just as interesting as a pump which acts as an artificial heart, whereas girls find the concept of the heart as a pump much more interesting.
- Learning something about the relationship between light refraction and the colour of light arouses little interest from either sex. Reference to a specific application (such as an aid for colour blind people) would be far more motivating. Discussion of how colours in the sky occur would also do justice to girls' fascination for natural phenomena.
- For girls the least interesting topic of physics is electronics. Yet they would be interested in constructing a lighting console, learning about the functions of electronic components in domestic appliances or discussing possible beneficial or harmful effects of microelectronics on our lives.

Students' interest in the subject of physics in comparison with their interest in other school subjects

In the canon of school subjects, physics is rated on average by girls consistently as the least interesting subject and by boys consistently as one of the most interesting subjects.
In grade 7 girls appear to suffer a considerable loss of interest in most subjects, apart from foreign languages, biology and sport. The boys do not appear to undergo such a clear interest loss. A polarization of interests can be observed in grade 8 on the part of the girls, whereas for the boys it apparently does not occur until grade 7.

At the end of grades 5 and 6, 45 % of girls who have already had physics instruction indicate high or very high interest in physics. At the end of grade 7 this figure has decreased to 30 %, at the end of grades 8 and 9 to 25 % and at the end of grade 10 it is only 20 %. For boys the percentages are considerably higher. At the end of grade 5 around 70 % of boys who have had physics instruction indicate high or very high interest; at the end of grade 10 the figure is still as high as around 60 %.

Female students in all six grades who indicate high or very high interest in physics express on average signicantly higher interest in other subjects (in particular biology, chemistry, mathematics and technology, but also geography, history and social studies) than their female peers with low to medium interest in physics. For the subjects German, foreign languages, art and sport there is no difference between the two groups. Male students who indicate high or very high interest in physics also express significantly higher interest in other science subjects than male students with lower interest in physics. In other subjects, however, there are no significant differences in interest.

School and out-of-school conditions in relation to students' interest in physics

On average boys achieve better marks than girls in physics. Boys' marks tend to improve between grades 7 and 10, whereas those of the girls tend to drop. An analogous development is that of the girls' self-evaluation with regard to their abilities and achievement in physics, which is distinctly lower than that of the boys and decreases significantly between grade 7 and grade 10, whereas that of the boys tends to increase. Girls who rate themselves as high achievers in physics indicate significantly less often than their male counterparts that they consider taking up a career which has "something to do with physics".

Girls have a lot less experience than boys in working with their hands, building things, handling tools and playing with technical toys.

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In their leisure time girls are distinctly less inquisitive about physics and technology than boys (i.e. they less frequently use TV and radio, books, magazines and newspapers to gain information), and they carry out significantly fewer repairs.

The girls are given technical toys significantly less often by their parents, they receive significantly less frequent stimulus from their parents to help with repairs, to have anything to do with physics and technology or take up a scientific career.

The results reveal a clear relationship between maternal model behaviour and girls' interest in physics. Girls and boys, however, when asked if they could observe an appropriate model behaviour on the part of their mother, gave an average response of between "seldom" and "never".

For both boys and girls, pre-school and out-of-school activities connected with physics and technology are significantly related to interest in physics, self-concept, and the estimation of the importance of physics and technology for the future in general and for the student's own later career.

How students perceive the climate of instruction is significantly related to their interest in physics and their self-concept. This relationship becomes even more distinct for female students in grades 7 to 10. For both girls and boys there is a close connection between their interest and how comfortable they feel in the lessons, how well the teacher is able to arouse their curiosity and how far the teacher is prepared to go into their questions and interests. Further important aspects are the extent to which the teacher gives a general outline when starting a new topic, and whether she/he connects the topic to the students' own experience, as well as the use of student experiments. If the latter are fun, allow new discoveries to be made and give the students scope to do something themselves, they appear to be even more important for girls than for boys.

Steps which would encourage girls to take more interest in physics include:

Reinforcement of the girls' self-concept by involving them appropriately in instruction activity and creating opportunities via student experiments for the girls to gain experience and confirmation of success (possibly in single-sex groups); provision of a "foundation" of information which enable the girls to achieve better orientation towards careers in science and technology and makes it clear how important it is for their future lives to deal with physics and technology.

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GENDER, VALUES, AND TECHNOLOGY: A CULTURAL PERSPECTIVE.

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Introduction.

In the spring 1986 I carried out some research in order to examine the association between values, self concept, and career aspirations among Norwegian young people . A total of 1364 pupils aged 15 - 17 years were included in this stydy, being drawn from randomly selected classes in the eighth and ninth grades of comprehensive schools and the first high school grade, irrespective of curriculum choice. All schools were located in central Norway. Questionnaire results showed that although most girls still want to pursue "traditional" women's occupations, there are a considerable minority who aspire to traditional male occupations. But only 13% of the girls would like to enter a technical or scientific occupation. By contrast, 47% of the boys wanted a technical or scientific occupation. (See table 1).

These are depressing results, given that Norway has for many years had legislation against sex discrimination in the labour market, and manadatory school programmes aimed at promoting greater equality between the sexes. A considerable fraction (40-45%) of the adult labour force is female. The country has a small population, and the school system is highly sentralised. It would seem reasonable to expect that efforts to promote women's participation in all sections of the labour market would achieve better results under such apparently favourable conditions.

Tab. 1. Career aspirations among boys and girls.

		OCCUPATIONAL CATHEGORY					
		SEX DOMINANCE *)			QUALITY OF WORK		
	N	FEMALE	NEUTRAL	MALE	CARING	TECHNICAL	OTHER
Girls	695	373	46	258	279	90	326
Boys	625	63	38	511	29	286	310
Total	1289	433	84	769	308	376	636

*) Sex dominance in occupation according to cencus 1980.

Why is progress so slow? Why do most girls still prefer traditional female occupations? Why do so many still see science as an inattractive alternative?

Science: Between capitalism and patriarchy.

Science and technology are closely linked to economic activity in a capitalist system. This can be seen clearly by looking at official statements about research policy in Norway. The Government has prioritized the long-term development of expertise, basic research and research programs which are thought likely to lead to technical progress and economic growth. (1) Three of five special development areas singled out in current research policy are of scientific-technological character: information technology (telematics), biotechnology, and research in oil technology. The close links between modern industry and science are obvious, and these links will be no less important in the future. The trend in industry is toward an even greater emphasis on science and technology.

Wiewed historically, there has been a close association between the mode of organisation of economic activity, and the division of tasks between the sexes. Production for profit has been dominated by men whilst improfitable but still essential reproduction has been women's domain. This is beginning to change. We have mentioned that there will be soon just as many women as men in the adult, wage-carrying labour force. Even if women to a conciderable extent have part time or poorly paid work, it would be quite incorrect to suggest that traditional division of tasks in the home is a prerequisite for capitalism. (2)

But patriarchy continues to exist in numerous forms, and expresses itself constantly. After the advent of legislation to secure equality between the sexes, it has become less overt.(3) The modern patriarchy iss less clearly expressed in the way work is organized, but perhaps to an even greater extent than before affirmed by cultural and psychological mechanisms. Cultural notions of masqulinity and femininity , manifested in the fashion and media industries, are transmitted to the youth. This transmission is so generally successful, precisely because gender is the most profound aspects of social life and personal identity in our culture.

Gender is associated with science too, not because capitalist interests dictate it, but for cultural reasons. This raises serious issues, because science becomes an important vehicle of the continuing association between the patriarchy and economic life in our society.

Science and gender culture.

How can we understand the close link between science and patriarchy, in its modern form?

Evelyn Fox Keller has shown how the paradigm of science in itself bears witness to male control and power.(4) This is possibly one explanation as to why women participate so little in scientific research. But I don't think it's the most likely explanation as to why young girls exhibit so little interest in science, especially physics, in school. At that stage they have too little knowledge of the basic idea of science to be able to reject it because of their value orientation.

What young girls do know is that they want to be girls. Gender is a fundamental attribute in our culture; you must be either the one or the other of the only two possible ones. (5) Gender is a part of personal identity, a gender-less identity being inconceivable, and gender is woven into the social rules that regulate relations between girls, between boys and between girls and boys. It means a lot for a girl to be reassured that she is really feminine, and she accordingly chooses to behave like a nice girl and at all costs avoids behaving like a boy. If we work against girls' efforts to be feminine, this will run counter to their identity-seeking, and we will also risk a collision with basic cultural imperatives.

Science is culturally defined as a masculine domain. Empirical studies from all over the world show that culturally determined gender mechanisms operate within science. Let me refer to some Norwegian results.

At the outset I showed how girls hesitate to encroach upon scientific fields, and to a greater extent than is the case with other masculine domains. Perhaps science is in some way especially masculine?

Findings about recruitment to scientific education reveal much the same sort of result. The Norwegian SISS project (Second International Science Study) showed that 16% of 17 to 18 year olds chose scientific subjects in 1983-1984. 43% of these were girls, and this would seem to suggest that we have a high female percentage of science entrants in Norwegian high schools. But the picture changes if we look closer at their choice of subjects. Between two and three times as many boys as girls choose mathematics and physics. The girls choose rather biology and chemistry. But the combination physics and mathematics is the only one which qualifies for entrance to advanced technological studies. Many girls make choices that preclude entrance to such studies. Indeed, it has beed suggested that the curricular options at this particular case is a rather dubious principle, since it merely amplifies the disparity between boys and girls. (6)

The SISS project showed that boys have more positive attitudes to science, especially to physics. The pupils regard researchers in biology as open, exciting, helpful, artistic, democratic, and considerate. Researchers in physics are seen as less open, egoistical, boring, authoritarian and inconsiderate. So far as experience of technical matters goes, girls have most experience of activities associated with the home,and the kitchen. Boys have most experience of cars, electrisity, mechanics and tools. Gender differences in experience of technical matters increase with age.

A study carried out in 1982 showed that gender is attributed to the various technical activities. It is seen as more suitable for boys to play with fireworks, electrical devices and radio, model trains and so on. (7) Similar results have come from the British GIST-studies. (8)

We have discussed recruitment, attitudes and stereotypes for a long time. We have solid enpirical background for a number of concepts at the theoretical micro-level. The more general notion of gender culture ought to provide a fruitful perspective for future analysis. Several arguments support such an approach. Culture is a notion which has implications for both individual identity formation and the rules of social interaction. It embraces attitudes, stereotypes, gender identity and conception of self. And it allows us to approach an analysis of those social dynamics which maintain the predominantly hierarchical relationship between the two sexes. A focus upon culture rather than characteristics or attributes renders analysis more complex, but we avoid an oversimplification of the causes of the phenomena we are concerned with. Indeed it might serve us just as well in the long run if we did not ask for the ultimate reason why girls reject science. Maybe we will get closer to the essential phenomena if we confine ourselves to describing how this rejection comes about.

Mechanisms which keep girls away from science, or at least some fields of science, are complex. Let me sketch out some of the most important.

- Boys and girls actively construct their own gender identity, in a process which begins at an early age. Boys become boys by performing activities within the masculine domain. Girls become girls by engaging themselves in care activities, by making up and dressing up, and by activities within a shared feminine circle, among peers. They do not become girls by attempting to get to grips with technology, indeed, quite the reverse.
- Both boys and girls construct their own subcultures. That of the girls is characterised by close friendship, usually dyadic relationships, which afford experience of social relationships from an early age. (9) Entering a masculine domain where the boys are active implies a break with the feminine culture, with the costs this entails.
- Boys and girls develop different value systems as a consequence of their cultural experience and identification. These value systems have a significant influence on educational and occupational choices.

This doesn't mean that boys' dominance over girls is irrelevant in the present context. Nor do I intend to suggest that girls are unaffected by the expectations of their parents or their school. Rather than conveying an impression that girls are helpless victims of dominant masculinity, however, I would prefer to emphasise girls active construction of themselves, their own situation and future. Rather than asking why girls don't behave as boys do, I think we should ask why girls choose in the way they actually appear to do.(10)

Occupational aspirations and self concept.

In the study mentioned at the outset, the pupils were asked directly about their most important motive for choosing that particular occupation. The majority of both boys and girls want an occupation which will be enjoyable and provide an outlet for their own abilities. Since boys and girls choose so differently, this implies that they have quite different views of their own resources.

All the pupils filled in a self-description scale, in essence built up along the lines of Bem's Sex Role Inventory.(11) No androgeny-scores were calculated. A factor analysis of the 24 items gave the following four factors:

FACTOR 1: ORIENTATION TOWARDS OTHERS, involving a description of oneself as considerate, kind, thoughtful and responsible.

FACTOR 2: INDEPENDENCE, the description of self as determined, independent, willing to stand up for oneself, assertive.

FACTOR 3: EMPATHY, involving description of oneself as one who consoles others, display own feelings readily, easily moved to feel for others, openminded.

FACTOR 4. COMPETITIVENESS. Description of oneself emphasising leadership, displaying knowledge ability, competitive ness, risk-taking, seizing the initiative.

Girls show the highest values for factors 1 and 3. Factor 2 showed no differences for boys and girls. The boys had the highest scores for factor 4. (All differences significant at $p \leq 0.01$.) Differences between boys and girls were most pronounced in respect of the empathy factor.

The pupils also completed a version of the Rokeach Value Survey (12). This was rescaled from a ranking to a Likert scale. The results comfirm the girls' "soft" value orientations: They score higher than boys for values such as openness, concern, and sympathy for others; boys score highest on values such as efficiency, skill, boldness, ambition, knowledge, and reasoning power.

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There was also a link between description of self and occupational aspirations. Discrimination analysis shows that factors 3 and 4 (see above) are the dimensions which serve best as predictors of a desire for caring as opposed to technical work. (See table 3.) Mean values for the four self-description factors are shown in table 2. There is a clear tendency to care and empathy orientations among those who want to take up work which involves looking after others, something we do not find among those who aspire to technical occupations. The most dramatic difference is that between boys who aspire to technical occupations and girls who aspire to caring occupations. Referring to our earlier discussion of the linkages between gender, technology and capitalism, it is surely alarming that these boys have such low scores for empathy. This would seem to support what many have been suggesting: technology needs girls. We might also point out that girls who do want a technological occupations are less empathic ($p=0.08$) and more competitive ($p<0.01$) than girls who aspire to a caring occupation.

Table 2. Four dimensions of self-description: Sex differences and differences between two groups of occupational aspirations. Mean z-scores. (N=1244. Group n in parentheses.)

OCCUPATION	FACTOR 1 OTHER-ORIENTATION Girls	FACTOR 1 OTHER-ORIENTATION Boys	FACTOR 2 INDEPENDENCE Girls	FACTOR 2 INDEPENDENCE Boys	FACTOR 3 EMPATHY Girls	FACTOR 3 EMPATHY Boys	FACTOR 4 COMPETITIVENESS Girls	FACTOR 4 COMPETITIVENESS Boys
CARING	0.20 (267)	0.20 (29)	-0.11 (269)	0.29 (28)	0.55 (275)	-0.12 (29)	-0.34 (268)	0.71 (29)
TECHNICAL	0.10 (87)	-0.11 (271)	0.04 (88)	-0.10 (279)	0.36 (88)	-0.55 (273)	-0.04 (88)	0.20 (271)

Table 3. Discriminant power for four self description factors in distinguishing those who aspire to caring vs. technical occupation.

FUNCTION	EIGEN-VALUE	% OF VARIANCE	CANONICAL CORR.	WILKS' LAMBDA	CHI-SQUARED	DF	SIGN.
1	0.29	100	0.48	0.77	162.5	4	0.00

STANDARDISED DISCRIMINANT FUNCTION COEFFISIENTS:	
FACTOR 1: OTHER-ORIENTATION	-0.08
FACTOR 2: INDEPENDENCE	0.08
FACTOR 3: EMPATHY	0.97
FACTOR 4: COMPETITIVENESS	-0.60

These results indicate that girls' preferences for care occupations and female dominated occupations, and their infrequent attraction to technical occupations, is associated with a desire to release what they feel to be their own potential and values. Girls don't think and act without thought, or without considering their future. They know what their strenghts are, and want to make use of these in later life. Is it really worthwhile to dissuade them from this, in view of the values they are concerned with?

Get science into the female world!

Many have claimed that girls avoid science because it has a masculine image. This is still a valid viewpoint. But we won't solve the problem by putting pictures of girls and women in textbooks or installing kitchen devices in science laboratories. A girl will hardly be tempted to disassemble a blender to see what it looks like inside. She will be more likely to use it to prepare a meal. For her it isn't a piece of technology, but a tool to serve quite distinct and, for her, more important purposes.

Strategies for securing a greater proportion of girls in scientific subjects have to be based on a grasp of feminine culture, a grasp which also transcends merely banal manifestations of that culture like sewing machiens and washing mashines.

Female culture is permeated by relationships, helpfulness, empathy - and wanting to look one's best. A lonely woman in a white coat behind a microscope, or a pretty girl in a saucy boiler suit on a windswept oil platform in the North Sea, are not images especially appealing to girls. We have to be able to show them the social aspect of science: that engineers must cooperate with one another, travel, meet people, that computer work means listening to others and helping them to solve problems large and small. If technology can be seen as a way of solving human problems, and not as an end in itself, the prospects of interesting the girls will surely be better. Relationships between girls can be a basis for such an effort: try to interest a group of girls who already know one another, so that the information given can be built into their "inner circle".

Better to look for the strenghts of feminine culture, and build on those. Bring science into the feminine cultural context, don't make it a threat to all that is seen as feminine. Gender can't be dispensed with, but we must try to make the cultural implications of gender less oppressive for women. We have to make the effort.

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KEEPING UNDERGRADUATE WOMEN IN SCIENCE AND ENGINEERING: CONTRIBUTING FACTORS AND RECOMMENDATIONS FOR ACTION

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Gender differences in enrollment and retention

It is well documented that, in the U.S., female students are less likely than are male students to initially choose undergraduate science and engineering majors (NSF, 1986). What is often less well documented is the lower persistence rates in science and engineering majors among women who initially major in science or engineering. Although studies often indicate that young women earn higher grades in college science and math courses than do their male peers, they are less likely to maintain high occupational goals and are more likely to switch from science to non-science majors (Berryman, 1983). Therefore, in the educational pipeline, women are leaving the science and engineering undergraduate track even though their initial interests are in science or engineering and their grades are comparable or better than those of their male cohorts.

Factors Affecting Recruitment and Retention

Academic Factors Traditionally, many of the variables used by U.S. institutions to predict a student's potential success in a career or major are measures of "ability" or skills in various forms. However, studies frequently find that higher SAT and GRE test scores predict choice of quantitative majors and courses and entry into graduate school fairly well for males, but not for females.

Student attitudes and experiences. While elementary age children of both sexes like math and science and hope to study more math and science, from about ninth grade onward, males express slightly more positive science/math attitudes and greater interests in science courses and careers (Malcom, George, & Matyas, 1985; Steinkamp & Maehr, 1984). National and individual studies have also confirmed that young women have less confidence in their math and science skills and abilities, and are less likely to participate in extracurricular science related activities (Stake, 1984; Matyas, 1984; Kahle & Lakes, 1983; Hueftle, Rakow, & Welch, 1983). It is clear that these factors are related to students' interests in science and math and they may affect their persistence, as well.

Finally, women who select science and engineering majors frequently must deal with the perception that career choice may conflict with or prevent future family responsibilities. Undoubtedly, family/career conflict continues to be an important consideration for young women choosing a career (Gray, 1983; McLure & Piel, 1978).

Influence of Significant Others. Teachers, parents, and peers are important factors in students' development of science and math interests, skills, and confidence. Unfortunately, research indicates that both parents and teachers display less confidence in females' math and science abilities and peers are not always supportive of young women who excel in traditionally masculine areas (Kahle & Matyas, 1986).

Finally, a lack of "role models" or "mentors" has often been cited as instrumental in the dearth of women entering science and engineering professions. Undergraduate women who have had a role model, compared to those who did not, hold higher degree expectation, are more likely to enroll in graduate school, and display greater career commitment (Speizer, 1981; Mokros, Erkut, & Spichiger, 1981).

Findings of the Current Study

Methods The study sample consisted of biology majors (N=466) at a large midwestern U.S. university. The following variables were obtained from university records: average high school grades and number of courses completed in science, math, English and foreign languages; high school rank; undergraduate grade point average; Scholastic Aptitude Test (SAT) scores (Mathematic and Verbal); and size of high school graduating class. In addition, using the above data describing previous students, the university has derived an equation to predict the first semester GPA (grade point average) for each student at the university. This calculated estimate, reflecting traditional "ability/skill" measures, also was used as a variable in the current study.

A wide variety of attitudinal variables were measured through survey instruments (see variables listed in Table 1). Surveys were distributed and collected during biology classes. Students were assured of the confidentiality of their responses.

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Table 1

Attitudinal Variables

Science Attitudes

- Perception of science ability and enjoyment of science
- Attitudes toward success in science
- Perceived parental encouragement to succeed in science
- Attitudes toward women in science
- Perceptions of peers' feelings about science
- Perceived science competition with peers of the opposite sex
- Perception of teacher's confidence in student's science abilities

Science Anxiety

- Laboratory/practical precision anxiety
- Science study test anxiety
- Quantitative conversion anxiety
- Observer anxiety
- Precision anxiety

Extracurricular Science Activity Participation

Attribution of Success and Failure in Science

- To ability
- To effort
- To task difficulty
- To luck

Family/career Conflicts

- Household responsibilities of self and future spouse
- Resolving family/career conflict situations

Science Role Model Experiences

- Number of role models encountered
- Relationship to the role model

****

Students were followed for one calendar year and then their final majors were classified according to the number of high school courses required for admission to each major. Majors for which the value of the following ratio:

$$\frac{\#\text{ science courses} + \#\text{ mathematics courses}}{\#\text{ English courses} + \#\text{ history courses} + \#\text{ social studies courses}}$$

was greater or equal to one were termed "science oriented" and those for which the ratio was < 1 were designated "less science oriented." It should be noted that the term "science oriented" is a relative term and indicates greater requirements of both science and mathematics in high school.

Stepwise discriminant function analyses were employed to determine which study variables could best distinguish between male and female students who remained in science oriented majors and those who did not (that is, switched to less science-oriented majors).

Results - Results are summarized briefly in Table 2. As expected, traditional measures (represented here by the "predicted first semester grade point average") were important predictors of retention for both male and female students, although in opposite directions. In addition, both male and female students who remained in science oriented majors delegated greater household responsibilities to their future spouses than did students of either sex who switched from science to other majors. It appears, then that males with more traditional sex-role values and females with less traditional sex role values were most likely to persist in science. Since women with college degrees tend to marry men with college degrees (Markham & Pleck, 1985) (and women in science often marry men in science), this finding poses interesting questions concerning future family and career planning for both male and female science students.

For male students, believing that their success in science

Table 2

Stepwise Discriminant Function Analysis: "Predictors" of Attrition/Retention for Male and Female Science Students

MALE STUDENTS

Variable	Rank[1]	Sig.[1]	Students remaining in science majors had
Predicted 1st semester GPA	1	.004	higher pred. GPA
Responsibilities of future spouse	2	.050	more resp. on wife
Attitudes twd. success in science	3	.056	success more imp.
Size of high school class	4	.085	smaller class
SAT-Verbal score	5	.087	lower score

****

FEMALE STUDENTS

Variable	Rank[1]	Sig.[1]	Students remaining in science majors had
Predicted 1st semester GPA	1	<.001	lower pred. GPA
Number of role models cited	2	.003	fewer role models
Semesters of high school math	3	.004	more math courses
Semesters of high school English	4	.007	fewer Eng. courses
Grades in high school science	5	.008	lower grades
SAT-Verbal score	6	.027	higher scores
High school rank	7	.050	higher rank
Respon. of future spouse	8	.064	more resp. on husb.
Attitudes twd. women in science	9	.073	more negative att.
Peers feelings about science	10	.076	more positive percep
Observer anxiety	11	.079	greater anxiety
Extracurricular science activities	12	.091	more activities

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[1] Significance indicates the significance level of the increase in Rao's V upon entry of the variable into the equation. The rank signifies the rank order of variables in terms of greatest contribution to increases in Rao's V, not necessarily the order of entry into the equation.

is important, attending a high school where classes were smaller, and earning lower scores on the SAT-V were also related to persistence. It may be that lower SAT-V scores lead these students to believe that science is a more appropriate area for them and may, therefore, increase their perception of the importance of success in science.

For female students, more factors seemed to be involved. First, a lower predicted GPA was related to remaining in a science major. This may reflect the fact that women who remained in science took more high school math courses and received lower high school science grades (possibly reflecting advance course taking). Unfortunately, data on the types of courses taken during high school were unavailable, therefore, this point is not fully resolved.

Also somewhat surprising were the findings on female science majors' attitudes toward women in science; confidence in women's abilities in science was negatively related to persistence in science-oriented majors. However, this finding may be spurious since students' perceptions concerning women's abilities in science were overwhelmingly positive. The maximum possible score (most positive perceptions) was 30 points. Of 564 students who completed the subscale, only 35 (6%) received a score of less than 20 points. Therefore, the differences of opinion between women who remained in science-oriented majors and those who did not were actually very small.

Women who remained in science-oriented majors also cited fewer science role models; however, they developed stronger

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relationships with the role models they encountered (data not shown). It may be that quality, rather than quantity, is the key to providing role model experiences. As expected, participation in extracurricular science activities was related to persistence in science oriented majors. Women whose friends supported their choice of a science major were also more likely to persist.

In sum, traditional measures of ability/skill are strong "predictors" of persistence in science-oriented majors. However, particularly for women, other attitudinal factors are involved.

Implications for intervention

At the precollege level - The findings of this and previous studies strongly indicate that factors affecting the retention of women in college science majors begin exerting their effects early in the precollege years. The findings of the current study are correlational, not causal, but they suggest that, in order to increase the retention of talented women in college science majors, young women should be encouraged to do the following before they enter college:

* participate in extracurricular science activities;

* take advanced mathematics and science courses in high school even though they may not be assured of earning an "A" (this assumes that the earlier interpretation of findings is correct); and

* develop a strong relationship with a science role model rather than/or in addition to just having minimal contact with several role models.

At the undergraduate level The strategies employed at the precollege level can be continued and expanded at the undergraduate level. It is especially important to implement these strategies early in the freshman year since attrition from science majors is greatest during the students' first three semesters at the university. Specifically, programs could be (and at several universities already have been) designed to:

* Increase peer support for female science majors. Women majoring in science often are widely dispersed across campus and can benefit from organized support/study groups.

* Provide opportunities for female students to develop a relationship with a science role model, especially with a female role model. Often, entering students are not experienced in initiating faculty relationships or they are to self-conscious to try to get to know faculty members. Students should be encouraged to develop relationships with faculty members and be provided with specific opportunities to do so. Female students also can benefit from interactions with role models close to their own age; programs should provide opportunities for final year students to be "big sisters" for entering female science and engineering majors.

Although the ideal situation may be for undergraduates to meet with role models "one-on-one," a Women in Science and Engineering Seminar can also be beneficial. Sessions can focus on family/career planning strategies, how the science system works in both the specific university and in the larger scientific community, and how to recognize and deal with discrimination. Essentially, there must be a way to integrate

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young women into the network of women in science and engineering early in their training. However, it is important that women faculty who are working to gain tenure be recognized and rewarded by their departments for participation in these role model programs.

In conclusion, current research indicates that factors at both the precollege and undergraduate levels are involved in the loss of talented young women from the undergraduate science and engineering pool. Fortunately, the same research also provides some guidelines for effective interventions which can be institutionalized at both the precollege and undergraduate levels.

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How girls and boys understand the biological contents

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Research about the student's (grades 8th) knowledge of biology indicated similar mistakes by students from different schools caused mainly by misunderstanding of that contents (Stawiński 1976). Later on understanding of biological handbook contents (for students grades 4th and 5th) was studied using special tests of handbook text and out-of-text elements understanding (Stawiński, Palka 1980, 1985; Palka, Piotrowicz, Stawiński 1983).
It was found that students acquire oft biological knowledge without sufficient understanding it and that they have difficulties in the comprehension of some biological handbook fragments.

Now there will be presented one part of the research conducted in the years 1985-1987 under the author's supervision with especial consideration of similiarities and differences between girls and boys. This research considered environmental contents (grades 4th to 8th), ecological contents (grades 8th), and plant physiology contents (grades 8th and 10th). To measure the degree of understanding handbook informations contained in text and in out-of-text elements (in figures, photos, charts, diagrams, tasks), and in separate instructions there were used specially tests of understanding. As indicators of understanding there were accepted the right solutions of test tasks, including :

- explanation of analyzed texts
- presenting examples illustrating the given questions
- analysing and explaining of figgures, photos, charts and diagram
- logical thinking and concluding
- apprehending and explaining of biological relationes and biological regularities (laws of nature).

By solution of test tasks the students could (and should) use biological handbooks,and texts of exercise instructions.The test examination of the understanding of physiological contents by students grade 8th include 10 tasks concerned photosynthesis as process of metabolism.On the basis of the text analysis,the students had to explain the factors which influence oxygen production and to represent this relationes by means of schemes or charts (task 1 and 2).After that they should indicate the understanding of figures illustrating the process of photosynthesis and its connection with chemical formulas (task 3 and 4).They also had to explain the text and schemes concerning the conditions of photosynthesis, and as well to recognize correctly record of that process. Further on they had to complete the scheme illustrating the metabolic changes of glucose (task 6).Last's the student had to prove that they understand the photosynthesis as an anabolic process (task 8,9,10) and the correct sequence of reactions.

These investigation were conducted under the author's direction by M.Jasińska,T.Jasiński and E.Komar.

The second test served to study the understanding of ecological contents included 16 tasks.The students had to prove the understanding of the text characterizing the population of living organisms (task 1a and 1b) and its peculiarities (task 14).Therefore the understanding of relations was studied presented by curves of serviving (task 2 and 7),by curves illustrating the relations between predators and their preys (task 3).Further more there were measured the understanding of such concepts as "age structure of population" (task 4,6,8,9,12,15),"reproductivity" and "mortality of individuals" (task 6,9,10,11,13).The member of the examing group were W.Stawiński,A.Maśnica,M.Miszczak,Cz.Mrowca,T.Ogorzałek, J.Sarosiek and E.Soszyńska.

To measure the understanding of 27 verbal-drowing exercise instructions in the field of the environment there was used the third test elaborated by J.Walentyńska.Each test set was composed of some tasks (6-7)closely connected with the contents of that instructions.

The understanding of the biology of plant reproduction and plant development was measured by means of the forth test elaborated by T.Domański and B.Krzyżanowska which consists of two parts,each composed of 10 tasks.Most of that test's tasks served to study the understanding the schemes of the cycles of development of mosses and ferns,and also to examin the understanding of the textes of handbooks concerned with these problems.

Results

The results obtained are presented in the following sections in relation to each knowledge contents and in relation to each group of test tasks.

Understanding of photosynthesis

The level on understanding of handbook information concerning the process of photosynthesis measured by the average number of points acquired by the tested students (grade 8th) did not show any greater differences as regards to their sex (Table 1).

Table 1.Students scored for the test of understanding biological handbooks(grades 8th,students'age 14-15 years).

Sex	Boys			Girls			Together		
Contents	Number of students	Total number of scores	Average number of scores	Number of students	Total number of scores	Average number of scores	Number of students	Total number of scores	Average number of scores
Plant physiology Photosynthese	49	492	10,0	53	496	9,5	102	998	9,8
Ecology	60	370	6,2	68	384	5,7	128	754	5,9

Table 2.Percentage predominance of positive task solution in test of biological handbook understanding (Photosynthesis.Grade 8th)

Tasks number	Differenze of positive solution in %	
	Boys (N=35)	Girls (N=41)
1	2	3

1	2	3
1.	-	+ 8,3
2.	+ 16,5	-
3.	+ 25,5	-
4.	-	+ 10,3
5.	-	+ 2,5
6.	-	+ 5,7
7.	-	+ 14,2
8.	+ 16,2	-
9.	+ 8,1	-
10.	-	+ 0,5

The analysis of the scores by applying test version A pointed to a little adventage of girls'scores (0,1 points).By upsuming scores of the two test versions (A and B) boys-student becomed adventage on the level of 0,5 points average(Table 1). The analysis of the students scores by applying test version A indicate that girls had won percentage advantage of positive solutions by six tasks (Table 2).More girls than boys under stand correctly :

i. the exersise directions and the meaning of figures in handbooks concerning the relations between light energy and oxygen production by photosynthesis (task 1),

ii. definition of the products of photosynthesis,and especially the definition of the main products of photosynthesis (task 4),

iii. transformation of glucose into starch (task 7).

But more boys than girls had better presented the diagram illustrating light influence on photosynthesis (task 2) and explained the schematical representation of the experiment on the conditiones of photosynthesis (task 3),and as well as the interdependences between the concepts of "anabolism" and of „photosynthesis" (task 8).

Understanding ecological contents

The average results of testing understanding the ecological handbook contents amounted in all students to 5,9 points. The differences of achievement between boys and girls scores amounted to only 0,5 points (Table 1 - ecology).

Understanding of environmental contents

The pupils of other schools solved the tasks of enviromental tests.

Table 3.List of the students'scores by testing with test of understanding the text of the direction on environmental exercises'

Class grade	Number of boys	Average number of scores in points	Number of girls	Average number of scores in points	Total number of students	Total average number of scores
4.	12	12,6	6	10,3	18	11,5
5.	16	9,4	14	9,9	30	9,6
6.	37	6,8	28	9,9	65	8,2
7.	25	7,6	21	8,7	46	8,1
8.	16	7,3	19	8,5	35	7,9
Total	106	8,1	88	9,3	194	8,6

In the lawest of the tested classes (grade 4th)boys had better average results than girls.In the next class (grade 5th)girls won sligtly better scores than boys.Its maximum adventage was obtained in classe 6th(grade 6th).But in two next classes (it is the classe 7th and 8th,grade 7th and 8th) the adventage of scores obtained by girls decrease (Table 3).

Understanding the cycles of plant development

At the level of the secondary school in class 2 Polish secondary school (lyceum)(grades 9 and 10) no greater average score differences between the students of both sexes were noticed (Table 4).

Table 4.Comparision of students scores in understanding the cycles of plant development (grade 10)

Students' sex / Contents	Boys			Girls			Total		
	Number	Total number of scores	Average number of scores	Number	Total number of scores	Average number of scores	Number of students	Number of scores	Average number of scores
Development of mosses	14	105	7,5	33	243	7,4	47	348	7,4
Development of ferns	20	180	9,0	55	476	8,4	75	656	8,7

The differences amount only to 0,1 points´(mosses) to 0,6 points´(ferns) with very little adventage of boys (Table 4). In some classes (grade 10) most girls achieved better results than boys. The obtained differences between girls´ and boys´ scores are comparatively very small. By means of the Students´ Test (Test t) was analysed the significance of that differences, without the test on the understanding of environmental contents - T_3. The differences obtained by means of the tests: T_1(photosynthesis), T_2(ecology) and T_5(ferns) appeared to be statistically significant at the level 0,1 %. But those tested by T_4(mosses) are not significant statistically (0,1%).

Conclusions

The results obtained by research are not univocal or equivalent in meaning. The data acquired by means of the "environmental" test (T_3) may point to some differences in the intelectual development of girls and boys at the initial stage of the pupils´ physical maturation. It can explain the advantage of girls scores in the lower classes (grades 5th-7th). Very little advantage of the boys´scores obtained in class 8th can reflect the decline of these differences in students in aged 14-15 years. Instead the research on the understanding of ecological problems (test T_2 version A) suggest some differences in the way of thinking of girls and boys.

In the next future, there should also be examined the question: if and which differences occure between girls and boys in the way of analysing handbook text and biological figures, and the methods used at solving biological tasks and problems.

The earlier research of the present author at the Conference GASAT - 3 in London did not indicate any greater deviations at the level of the boys´and girls´activity in the lessons of biology conected with observations and experiments.

But it was ascertained that some activities were often made by boys, and other by girls (Stawiński 1985).

The results of research actualy presented on the understanding of biological contents do not indicate any differences in intelectual possibilities of boys and girls.

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Affirmative Action in Public Secondary Education in Canberra, Australia

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Issues vital to Australia's future are the impact of science and technology, the role of education in preparing young people for living and working in an increasingly technological society and the need, still existing despite legal equality of access, for affirmative action towards the goal of equality of educational opportunity for all.

Focussing on the issue of affirmative action for girls within the public compulsory education sector this paper describes:

. national policies aimed at eliminating inequities in educational provision particularly in science and technology;

. initiatives towards this end by the Canberra public education system;

. community groups working for increased participation and equity.

Collaboration and interaction of these in attacking the problem are illustrated in two case studies of educational programs in action.

In the complex constitutional relationships in Australia each State Government has the major responsibility for administering and funding public compulsory education. The Federal (Commonwealth) Government initiates national programs and provides supplementary finance for the States, advised by the Commonwealth Schools Commission (CSC). In the Australian Capital Territory (ACT) public education is funded by the Commonwealth Government and administered by the ACT Schools Authority.

Federal Government recognition of the issue of inequity is shown in policy statements concerning the under-representation of girls and women in science and technology: the Commonwealth Schools Commission Report for the Triennium 1976-78 (CSC, 1975) - the first in-depth study of

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girls and schooling ever undertaken in Australia - categorized girls as a disadvantaged group, highlighting differentials in mathematics/science performance between the sexes, concluding that "The Commission accepts the need for schools to reflect more directly the changing role of women in society and positively to assist girls to an enhanced perception of their potentialities". Girls, School and Society (CSC, 1975), the report of the consequent study group of the Commission succinctly analysed the "hidden curriculum" and structural barriers to participation. The Report for the Triennium 1979-81 (CSC, 1978), acknowledged considerable activity aimed at eradicating discrimination, but stated that the presentation of physical science and mathematics subjects to encourage confidence and success in girls remained an unsolved problem. Girls and Tomorrow: The Challenge for Schools (CSC, 1984) concluded that greater and more comprehensive efforts were still needed towards equitable outcomes and recommended a national policy towards this end. The hard-hitting report Education for Girls (1984) of the Victorian State Education Department in co-operation with other State and Territory Education systems showed their support for federal policies, concluding that "schools are virtually providing a different education to the sexes .... girls are left technologically illiterate and deprived of a wide range of post school options ...". The interim report, A National Policy for the Education of Girls in Australian Schools (CSC, 1986) called for fundamental curriculum changes in gender-stereotyped areas to overcome factors militating against girls' achievement in these areas. A similar thrust appears in other reports focussing on technological change - the National Technology Strategy discussion draft (1985), prepared by the Departments of Science and Industry, Technology and Commerce, emphasizes the need for increased participation rates "in technology related subjects and specially amongst women ..." and Education and Technology (Australian Education Council, 1986) stated policy and program options to assist the education system to deal more constructively with technological change. Concern by teachers is shown in the Australian Science Teachers' Association's (ASTA) report of a CSC funded project Girls and Women in Science Education (1987) - a comprehensive and powerful document in its analysis of issues, formulating strong recommendations and outlining workable and realistic implementation strategies.

Canberra (population 263,000), the Australian national capital, is the urban centre of the ACT and the seat of the Commonwealth Government. Its homogeneous and well-educated society and the geographical compactness of the city, facilitate the successful networking and mutual support of those whose concerns include full participation, equitable access and active involvement in science and technology for secondary school girls. Canberra people are fortunate in having ready access to and support from the tertiary institutions which include the Australian National University (ANU), the Canberra College of Advanced Education (CCAE) and the Colleges of Technical and Further Education (TAFE).

Canberra groups working towards common equity goals include:

. Women in Science Enquiry Network (WISENET) - aimed at increasing women's participation in the sciences and at linking people working towards a more participatory and socially useful science was formed in 1984. Open to women and men, WISENET is voluntary, participatory and non-hierarchical, providing a supportive environment for free discussion and action. The network comprises local groups and individuals acting autonomously in response to local needs, linked nationally by the WISENET journal. Canberra members have met regularly to discuss Health and Education issues, have organised more general public meetings and have contributed as resource people to affirmative action projects such as CCAE Career days, the CSIRO Women-in-Science Project and the CCE Affirmative Science courses. Group members maintain close links with the Canberra Mathematical Association and

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the ACT Science Teachers' Association. A current undertaking, funded by the Federal Government's Office of the Status of Women and with help from CSIRO is the compilation of a Directory of Women in Science and Technology in Australia.

- ANU Women in Science Discussion Group (WISDG) - open to campus women and alumni provides a supportive forum for the regular discussion of issues relating to science and to women. WISDG is used as a contact and resource by schools and others involved in science education.

- ANU Centre for Continuing Education (CCE) - fosters the "learning society" by enriching contacts between university and community. In 1986 an affirmative action course for women, "Alice Through the Microscope - Science and its Social Implications" was run with WISENET and WISDG members acting as voluntary session leaders. In 1987 a course of practical science lessons in school laboratories will be led by volunteer women science teachers with primary school teachers being especially welcome to attend.

- ACT Science Teachers' Association (STA*ACT) - affiliated with ASTA is open to all teachers and has over 150 members. Activities include an annual conference, a Science Fair, liaison with scientific societies, coordination of a Science in Schools Week and collaboration with CSIRO and BHP on the prestigious BHP Prize.

- Women Interested in Education - initially an informal group, now formalised by the ACT Schools Authority, open to women from Commonwealth Departments, the Schools Authority Office, public and private schools, TAFE Colleges, the CCAE, the ANU and the general community who share an interest in promoting effective education for girls and equality of opportunity for women. More than 100 women gather bi-monthly to exchange ideas and information and to strengthen the network.

. CSIRO - Women-in-Science Project - initiated by the Commonwealth Scientific and Industrial Research Organization, the largest scientific research body in Australia. In line with CSIRO's commitment to science education and equality of opportunity, the project aims to increase the participation of girls in science and mathematics studies at senior secondary school levels, thus promoting community scientific literacy, encouraging informed debate on scientific issues and expanding career options. The school program comprises a CSIRO video "Women in Science" depicting the work and careers of seven CSIRO women, structured class discussion and visits by CSIRO women scientists and technicians. In its first year over 2000 girls around Australia have participated.

. Questacon - a participatory hands-on science centre, established by the ANU and described as the most imaginative and innovative method presently existing of stimulating an interest and awareness of science in Australia, was initially funded in 1979 as a national project by the CSC. Questacon is staffed by enthusiastic volunteers who explain the exhibits and give informative and entertaining half-hour science shows. The centre has attracted more than a quarter of a million visitors and has continually extended its opening times, range of exhibits and activities, which now include a travelling national science circus.

All involved in the education of young people have access to the above to supplement and complement formal education initiatives. In Canberra the government school system is structured on the concept of a neighbourhood based network of schools with a high premium on public participation and community involvement, devolution of control, and variety and diversity of provision within a coherent system. The ACT Schools Authority strongly supports the nation-wide Participation and Equity Program (PEP), aimed at fostering equal educational outcomes.

Projects illustrative of current initiatives in ACT government schools aimed at gender equity are:

- *Equity for Girls at Canberra High School* - an all-school approach, 1984-87 (Canberra High Shool, 1987). Like all ACT Government High Schools the school is regional, non-selective and co-educational, drawing its 800 students mainly from neighbourhood primary schools and taking them through Grades 7-10, with almost 80% continuing to a Secondary College for Years 11-12. The 72 teaching staff are employed by the Commonwealth Teaching Service. The school, under the governance of a school board with community, teacher and student representation, has considerable autonomy over program formulation within the framework of Authority policies. Assessment is internal and continuous, the Secondary Colleges imposing no special entrance requirements. The Equity for Girls project arose from awareness by a core of staff members of the need for change and from individual attempts to implement non-sexist practices in the class-room. In July 1983, Senator Susan Ryan, the Commonwealth Minister for Education, launched PEP. The school applied for and obtained a grant which provided official sanction and some resources, but the bulk of the task of devising and implementing strategies and collecting data fell to the project team of 17 teachers, mainly working without relief from normal duties. The project could not have eventuated without the full support of the Principal and the School Board. Among the aims of the project were the broadening of girls' career options by encouraging them to continue with higher level mathematics and the physical sciences and to increase boys' participation in humanities, arts and home economics. Strategies used involved the introduction of new course units and methods, the monitoring of texts and library resources, observation, analysis and discussion of class-room interaction and use of playground space, allocation of scarce computer resources and the formation of some single-sex science classes. A vital aspect of the program was open discussion with students including a Gender Equity Workshop for staff and students with facilitators from the Authority's Consultants section. The Student Representative Council was involved with action research in the class-room and in the playground. The project team, aided by the Authority's Youth Services Section, used other resources particularly as related to career aspirations. A "Futures" Program was complemented by girls' attendance at "Girls in Trades and Technical Careers Days", "Girls in Maths and Science" programs and Link courses at TAFE colleges, while Work Experience in non-traditional areas was encouraged. Apart from Schools Authority consultants, speakers and discussion leaders have come from CSIRO and WISENET, while CCAE student teachers on practicum have been active in data collection and evaluation. Parents have been involved in planning and discussion. Another strategy has been involvement with the Family Maths Project Australia (FAMPA) - a national program, patronised by the Australian Institute of Engineers, enabling families to work together to improve their maths understanding.

Project implementation has involved the efforts of staff, students, parents and community towards changing the pre-existing pattern. The essential communication of the aims and processes of implementation has not been easy. A video-film and a short documentary screened on the local commercial television station effectively supplemented meetings and bulletins. A longitudinal survey has been maintained to provide data for future development. The students themselves are becoming aware and are devising new strategies, and a PEP grant to a regional gender equity network provides the means for extending the project outside the school.

. The Duffy Primary School Project: Equity for Girls (and Boys) - a regional project to give girls (and boys) more equal outcomes from the educational process. This project which had a full-time coordinator funded by PEP in 1985-86 was an extension of initiatives originating at Duffy Primary School in 1979. Its most significant additional feature is the formation of a network of schools comprising preschool, primary school, high school and secondary college and including the local Child Health Clinic. Thus, parents, teachers and children from 0-18 years were brought together to work towards non-sexist education for all. Each school formed a committee to implement Schools Authority policy on gender equity. Parents, teachers and students worked together to raise awareness of the issue, hitherto 'almost invisible', and strategies to implement change included action research (using students) into the use of teacher time, playground space and resources. Developing this vertical network has induced recognition that the lower participation of girls in higher level mathematics, physics, chemistry and computing at college is the end product of an accumulation of small and often previously unrecognised barriers. The recognition that some of these factors are traceable even to pre-school and early childhood in the home underlines the need to develop counter-acting strategies. Considerable time, resources, persistence and continued collaboration are seen as essential for effective change.

Obviously, government policies are not sufficient of themselves to remove the structural barriers filtering girls out from participation in science and technology subjects. The persistent activities of committed individuals and groups, working collaboratively and with diverse strategies, within the framework of national policies, is needed to achieve the goal of participation and equity.

A complete bibliography is available from the author.

ON THE CONCEPTS OF TEACHING AND TECHNOLOGY IN THE TECHNICAL SCHOOLS IN DENMARK (1)

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Subtitle: How is the message passed on that vocational education is for men only?

1. The Project of Girls & Computing

The Project of Girls & Computing at the Technical Schools in Denmark was initiated by the Directorate of Education and motivated by the assumption that girls may have greater difficulties in achieving the aims in the subject of computing in the technical schools, because the subject is incorporated in vocational education.
On the basis of this assumption the Project Group (2) was commissioned to outline a project, with the purpose of developing the subject of computing and thus improve the girls' benefit of the education.
The members of the group agreed that the subject was the problem. If the girls have difficulties in achieving the aims in computing, the explanation is to be found in the content and methodology of the subject, and in the way in which the subject is taught, as it is the case in other subjects as for instance physics (3).

So we asked ourselves:
On the one hand - do boys and girls in fact have a different kind of interest in computing and a different behaviour in class/a different benefit from the teaching?
On the other hand - if so, which qualities characterize computing as a boys' and men's field and make the subject different from subjects conceived of as girls' and womens' fields?

At the same time we had an idea that the answers to these questions might be the starting point of a further investigation of the "hidden curriculum" in the education of apprentices in male trades.

How is the specific socialization of the two sexes expressed in the notions girls and boys have, of the relevance and meaning of different subjects and of their own abilities in relation to these subjects?

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What ideas do girls and boys encounter in the technical schools - and especially in "male" fields - about the relevance and meaning of different subjects?
What concept of technology - of the relation of human beings (man and woman) to raw materials, tools and machines is passed on in the teaching process?

What consequences might that have for their benefit from education?

2. Theoretical background

We know that, during their childhood, girls and boys are met with different expectations and thus tend to express different attitudes and behave differently, while playing and in the classroom (4).

When girls play they discuss the way the game is to take place before they begin.
The boys decide who is going to be the leader.
Girls seek community, boys seek competition.

In class girls demonstrate a need to be confirmed by the teacher and obtain hers/his personal acknowledgement and sympathy, whereas boys seek success in the public area of the classroom.

We know that educational environments are characterized, by a separation of different subjects. And that different subjects develop different environments in class, thus passing on certain expectations of attitude and behaviour to the pupils/students, favouring one sex or the other and encouraging the further development of the sex roles.

We assume that girls thrive and develop well in class when a secure social environment is incorporated into the way in which a subject is taught, and that they experience environments, characterized by competition, as unsecure.

We assume that the way girls and boys experience different environments in class, related to certain subjects, form a basis of their notions concerning their own abilities. At the same time, of course, these notions are notions of the abilities of the other sex, and so the children meet the prevalent social ideologies of the two sexes in their mutual classes.

We assume that this encourages girls and boys to use some of their human resources while not even being aware of others.

These assumptions imply that even though girls and boys apparently thrive and develop in their "own" subjects, the way in which these subjects are conceived of and are taught inhibits both girls and boys in the learning process.

The notions of the relevance and meaning of certain subjects in different lines of education can be related to the prevalent social ideologies of science and technology.
Throughout history, the ideology of science has contained different ideologies of the sexes, expressed in the ideas of the relation of human beings to nature (5).

It is our assumption that the ideology of science are related to the ideologies of technology, and that human ideas of the relations of human beings to technology contain ioeologies of the relation of woman to man.
We assume that the prevalent concepts of the two sexes are integrated in the ideology of technology that is passed on as an essential part of a "hidden curriculum in vocational - and other education.

This knowledge and these assumptions form the basis of our examination of the subject of computing in the technical schools.

3. The Subject Fields at the Technical Schools

To give you an impression of the profile of computing we must describe the subject as part of an educational structure, and examine some prevailing notions of the meaning and relevance of different subjects.
The educational structure is characterized by the separate description of core subjects (for example Danish and Foreign languages) and subjects directed towards the trade (for example mechanics and electronics).
These two subject fields are described on the basis of two different theories of education.
For an outsider, the difference between core subjects and subjects directed towards the trade becomes visible in the curriculums. The "trade subjects" are described on forms as "items", presupposing a hierarchical structure of goals and content, outlining the attended behaviour of the apprentice at the end of the sequence. The core subjects are described in prose and the description contains pedagogical and methodological reflections as well as the laying out of goals and content of the subjects.

The curriculums of the core subjects have been criticized of being to "loose" thus giving the individual teacher "too much freedom" in planning her/his

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teaching.

The curriculums of the "trade subjects" are based on a sort of "instructional technology".
Apprentices are conceived of as a "raw material", teaching as a "technique", and the benefit of the apprentices as a product in the form of marketable labour.
The consumers of this product are the trades and the industry.
The curriculums are made to rule and control the teacher and secure the uniform quality of the product.
The intended result of the teaching is described as the "terminal behaviour" of the apprentice.
The teacher is programmed to program the apprentices.

Obviously, these ideas are not "consumed raw" and realized by the teachers. Still they are voiced in different ways in the official and unofficial debate about the education of apprentices, and are part of the complicated web of expectations the teachers and the apprentices are confronted with, and confront each other with within the system.

The goals of the core subjects are mainly conceived of as relating to the personal development of the apprentices.

The apprentices are conceived on as individuals and the education should improve their abilities and their possibilities of influencing their own environment and society as a whole.

At the technical schools the standard of values contained in the philosophy behind the curriculums of the "trade subjects" prevail - also in the evaluation of the core subjects.
The teachers in the core subjects are met with the demand that their teaching should be relevant to the "trade subjects".
In the curriculums this is verbalized as a recommendation to "integrate" core subjects and "trade subjects" in different degrees and ways.
As a rule, teaching guidances describe this integration in consideration of the special goals of the core subjects.

To obtain homogeneity or uniformity the trade area of "Iron & Metal" have begun to describe the core subjects on forms in the same way the "trade subjects" are described. This does not suspend the original curriculums.

However, it does make visible the way in which the core subjects of education of apprentices are evaluated and submitted to "productivity standards".

4. The hidden curriculum

The curriculum, hidden in the separate description of the goals related to the individual and the goals related to the trade, is that personal life and social life are independent parts of human life. That subjects, related to working life constitute "real" education. That these subjects are more meaningful and relevant than other subjects, and that within the teaching of these subjects there is not the time, nor the ressources to occupy yourself with the interests and needs of the apprentices which are not at the same time the interests and needs of their future employers.
At the same time the world is mapped out as consisting of secure, "familiar" spheres on the one hand and of insecure and demanding ("tough") spheres on the other. Life is conceived of as "real" life (the daily work, the period of your life when you are "active") and what comes before and after, and serves only to enable you to work.

The content of the subjects (including the concept of technology) becomes something human beings must submit to in order to make their working power saleable, not something they can use in their own interest and in the interest of society.

In this conceptual frame it may be difficult to reach the goals of qualifying even of motivating, the apprentices to influence their surroundings.
The mere notion that influence is a possibility may be experienced by the apprentices as a "double bind".

One message is to submit to and "keep up with" technology, the other that they are able to form their own life and to influence the social development.
How do the apprentices react to this "double bind"?
As teachers at technical schools, we have heard apprentices expressing the attitude that they have no interest in learning about their own interests because this will not be in the interest of the employer.

Teaching core subjects we are often confronted with negative formulations of the goals in the education of apprentices - we are consistenly told what is not relevant.

Let me try to set out what is considered relevant.

The "product", that is the apprentice leaving the technical school, at the end of the basic year to serve her/his apprenticeship in a firm, has to accept that the manager is always in his right, respect working hours, do whatever job she/he is told to do, no questions asked, efficiently and well.
If she/he commits errors, they must expect to be met with various degrees of rudeness.
They must do all of this without complaining.
And they must conceive of their own situation as a reflection of democratic justice.

The reward for repressing your own needs, feelings, and opinions is - if you are a boy - to gain the status of a "real" man, and then of course, when your trials are over, to assume the position that allows you to "harden" the next generation.

Such standards of value seem immediately "old-fashioned" and appear to belong to another era - or maybe to the military.
But they can be found in a modern version where "development" or "progress" has taken over the part of the manager. The power has become abstract and prehaps more massive because it is no longer exerted by a person. "Development" or "progress" is regarded as given, as a being in it´s own right. The role of human beings is to "keep up with" development, to "jump on the wagon". Human beings have become an obstacle to "progress".

Again - these notions do not exist in unmodified form in class, primarily because teachers and apprentices are humans and not robots, secondly because other standards of value and other theories of teaching are inherent in the system.

Neither are they especially related to the technical schools, rather part of a dominating social ideology of human work, rooted in the selling and buying of labour, and so, the apprentices have met them earlier in life, in various forms.

The socialization of apprentices continues the early socialization of the child in the family and in the school.

5. Girls & Boys in "Male" Trades

How is the situation of girls in "male" trades?
Is the feminine sex role of any use to girls in "Iron & Metal"?

All of their lives, girls and boys have been brought up to play different parts:
They have been met with different expectations and as a consequence, they differ from each other in attitude and behaviour.
How do their sex roles fit in with the expectations and notions they meet at a technical school?

It is no coincidence that "Iron & Metal" is conceived of as a typical male field of education leading to male trades.

Boys have a need to arrange their world in a hierarchy, to have the leader "ponited out", in order that the game - the fight for power - can begin. They submit to the "rules of the game" to get a chance to win. This attitude will help them to accept the hidden curriculum at the technical school.

The concept of technology passed on in the teaching process also contains concepts of power and impotence.
Technology is conceived of as things, as tooles and machines, but not as social relations among human beings.
The apprentices must learn to "master" technology.
Progress is the leader of the race. The apprentices are the runners trying to "keep up with" or overtake development.
Those who do are the winners, the others are loosers.
Security is knowing the rules and whom to obey.

"Iron & Metal" make "men" out of boys!

Girls have a need of being accepted and confirmed, and a need for a fund of common experiences and a socially "secure" environment.
They have not been brought up to partake in the game. They are shut out and considered born loosers in advance.

When girls are urged to enter male-dominated fields of education, they are asked to satisfy expectations, differing widely from those they have hitherto been confronted with, in an environment conceived of as "male" and passing on the same standards of value and notions of sex that has been, and still is, incorporated in the specific socialization of the sexes.
This must be felt as a "double bind".

The girls can submit to the socialization as if they are boys, that is try

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to be "as good as" the boys on male conditions, risking in their own eyes and in the eyes of other people - to loose their "femininity".
This will expose them to the aggressions of boys and men who have hitherto been "loosers" in the system, but have been able to adhere to their "male" identity and their self-esteem, because they were at least part of a male society, closed to women.

Or they can hold on to their "femininity", risking in their own eyes and in the eyes of the boys to be labeled second-rate labour and made "substitute players".

6. Computing

Computing has developed as a subject, within the educational structure, I have described above. Computing is a core subject.
This was the starting point of our examination.

It was (and is) our hypothesis that possible explanations of differences between the sexes, concerning their interest in and benefit from different subjects, must be sought in the contents, methodologies and ideas about teaching processes connected with the subjects. So we chose to examine what we have called the "profile" of computing:

1. We made a questionnaire covering the teachers of computing in a male and a female field (Iron & Metal and Food), followed by individual interviews

2. We made class room observations and interviewed the girls about computing

At the moment we are working on the report from our examinations and preparing an experimental strategy of teaching in computing in the two areas. The project is to be completed in the summer of 1987 (6).

In the first part of our examination, we have wished to form an impression of the ways the teachers conceive of the goals of the subject of computing, which subjects they connect computing with in their own mind and in their way of teaching, how they make use of computers in the process, and how they experience girls' and boys' interest and behaviour in class.

In the second part of our examination, we have wished to observe the attitudes and behaviour of girls and boys in computing, and form an idea of the ways the girls conceive of the subject, and of their own background and abilities concerning computing.

6.1 The teachers

Among other things we asked about the teachers' age, sex, educational background, and other teaching subjects because we assume these matters are relevant for an understanding of the role of the subject in the traditional educational structure.
We will not give a detailed account of our examination in this paper, but merely report on the matters we find significant.

The teacher of computing is a man.
He does not teach languages.
The teachers connect computing with either "trade subjects", or a subject field consisting of core subjects concerning society.
The way the teachers relate computing to other subjects is by dealing with topics also present in these.
Usually he demonstrates how computers can be used in other subjects in order to motivate the apprentices to learn computing.
The teachers think, the apprentices should be educated as users - and that they have no use for programming.

They attach importance to demystifying the machine, and think computing should be phased out as a self-contained subject while computers should be used everywhere in the educational system.
These ideas about computing are consistent with the concept of technology passed on in the education of apprentices in "Iron & Metal".

6.2 The Textbooks

In the class we observed, the apprentices used a textbook (7).
Studying the book my attention was drawn to some characteristics I have later recognized in other textbooks for computing.
The books have separate chapters of using/programming the computers and of the social consequences of computers.
There is no coherence between the separate chapters.
Technology is described as something given, possible problems are understood as results of ignorance or malintent of the users. The process of creating technology has become invisible.

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The characteristics of the development accentuated in several textbooks is it´s speed and it´s force. The characteristics of the computers are their speed, capacity, and price.
The pedagogical ideas implemented in many textbooks are similar to the ideas of instructional technology described above (part 3). At the end of each chapter you find a number of questions or problems. If you have read the chapter, you have been programmed to answer the questions or solve the problems.

In this way a message is passed on to the apprentices that each question has one and only one answer, each problem only one solution.
The problems involving the use of the machine most often demonstrates the usefulness of technology.
The problems involving programming consist of an unproblematic translation of material into high-level programming language.

6.3 The apprentices

The teachers´ experiences, concerning the interest and behaviour of girls and boys in computing, differ widely, but most teachers have experienced differences.
While some teachers think the girls have a suitable way of working, others relate this ability to the boys. Still, we recognize two main tendencies, in the specific way in which the teachers describe the apprentices´ attitudes to the computers:

"I am alienated from technology"

and

"I want to "master" technology"

The teachers think that more girls feel alienated, while more boys want to control technology.

The feeling of alienation may result in more or less suitable ways of working: the apprentices may be passive and resigning, or they may work dilligently and systematically. Being systematic is frequently mentioned as a strong ability with the girls.

The want to "master" technology may be expressed in a frustrated and aggressive behaviour (when you do not succeed) or in a playful and experimental way of working.

Even though these attitudes seem to be opposite, we think they are different expressions of a basic alienation from technology, experienced either as an anxiety caused by the machine or as machine fetichism.

We have not yet drawn a conclusion from the results of the classroom observations but I shall account for some main tendencies.

Girls work more systematically than boys do.
Girls want to know the background and the meaning of the problem they are asked to solve by the use of the computer.
Boys want to know what to do.

In "Iron & Metal" where there were few girls in the class the girls had an opinion of their own abilities differing from that of the girls in Food' who were a majority.
The girls in "Iron & Metal" interpreted their own attitudes as an expression of ignorance.

As a tendency the girls thought of themselves as poor at computing, while the boys seemingly felt they did well.
It is uncertain which consequences the self-concepts of the two sexes may have for their concepts of the opposite sex.

It is especially interesting that the tendency we found in "Iron & Metal" was not seen in "Food", neither in our observations of the girls nor in our interviews with them.
So we made an interview with four girls who had been in a girls only class in "Iron & Metal". These girls expressed self-confidence and seemed to feel competent, as did the girls in "Food".
Maybe the girls are supported in creating a common fund of experiences that confirm them and make them feel secure, when they are many in a class.

In the interviews the teachers expressed the opinion that the girls are not as interested in computing as the boys. This did not imply that the girls are poorer at computing. They also had the impression that the boys often knew about computers in advance, although they were overestimating their own abilities.

Most of the girls we interviewed told us that they knew about computers in advance, that they are very interested in computing, and that they want more challenges in the subject. They want to learn programming. They think it is "dull" just to operate the computer. They do not want to be "just" users. They feel competent.

Except for the girls who had formed a minority in class in "Iron & Metal". They expressed the opinion that they were not as good as the boys, that they must submit to the conditions imposed upon them in a male-dominated trade.

I would like to stress that these attitudes can not be explained by the teaching process of a single subject. They are rather resulting from the bad conditions of growth a girls´ culture has in a male world.
The girls simply did not make themselves visible as girls. They formed their own private, protective recesses, breathing holes, enabling them only to survive.

The difference in the observations and interviews between the two areas, compared to the interview with the four girls from the girls only class, lead us on to the question: Is the interest and the behaviour of the girls interpreted in two different ways, depending on the educational environment (male-dominated or not): On the one hand as an expression of technological interest and competence, on the other hand as an expression of technological ignorance and helplesness.

Furthermore: Is the eagerness of the boys to work/play with the computers interpreted as an expression of technological interest and competence or as an expression of impatience and immaturity, depending on the educational environment?

If we evaluate the girls´ and the boys´ behaviour, in the light of the hidden curriculum, it seems to us that the attitudes of the girls are in opposition to the demand of doing what you are told to do. While they are prepared to follow the instructions of the teacher, they still want to know the background and the meaning of the "job".
The boys may not be prepared to listen, but they are prepared to do the job no questions asked.

However this opinion is not consistent with the usual notion of girls as more authoritarian than boys.

Maybe this has to do with the difference in social background concerning the girls and boys we have observed and interviewed. Regrettably, we have not had the ressources enabling us to include the social background of the apprentices in our examination.
We have no doubt that a knowledge of the combined effect of sex and social background on the interest, attitudes, and behaviour of the apprentices will modify our theories on differences related to sex.

Our examinations do not confirm the assumption that the girls may not reach the goals of the subject of computing. But it does show that girls at the technical schools - and also in the subject of computing - face special problems.
One problem is that they are so few that they are unable to form a girls' culture, enabling them not only to survive but to develop their own identity in relation to technology, and to leave their marks on the educational environment and on the trades.
Another problem is that the pedagogy practized at the technical schools, pass on un understanding of technology characterized by the invisibility of human beings as creative beings, and by the notion of people as users who can choose to "keep up with" technology or not, and who are responsible for any problems related to technology.
This notion is a part of a conceptual frame that also contains traditional ideas about the sexes on the basis of which girls' and boys' attitudes may be interpreted to fit the pattern.

7. A Pedagogy for Girls at the Technical Schools

How do you develop a pedagogy for girls, forming a minority in the technical schools?
I think neither girls nor boys thrive and develop in accordance with their abilities in male-dominated fields of vocational education.
To me, creating a pedagogy for girls is developping a new pedagogy.

The long term goal of developping the pedagogy in the technical schools is to implement a new concept of technology in the education of apprentices, containing more fruitful notions about the different subjects and about femininity and masculinity.

A strategy to bring more women into male trades will not succeed if the subjects of the education remain "male" in content and form (8).
Girls and women have no interest in male trades as such.

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Neither have boys and men!

So we must work on a short and a long term basis.On a short term basis it is essential to support and challenge girls choosing a technical trade, so that they can finish their education, thereby securing them the possibility of establishing a fund of common experiences, confirming their choice and forming a basis of a development of a female identity in the technical trades.

Supporting the girls is primarily making them conscious of their own technical qualifications by making these visible in class to the boys and to the girls.

This can be done - for example - by occupying yourself with the problems of the boys to compensate for the effect of the tendency in both boys and girls to constantly notive the "errors" of the girls, and ignore those of the boys.

In this connection it is important to be aware of the way campaigns for "women in male trades" picture women and men.
The different campaigns overwhelm us with arguments, implying that the girls are "just as good as" the boys.
This way of putting it make the sexes competitors, competing in accordance with "male" standards.
On men´s terms?
I do not think so.

But on the terms contained in the hidden curriculum described above.

So it is important that problems in the process of working and learning about technology are presented and treated as common problems, not as the "errors" in or defeats of individual apprentices (girls or boys) in the competition of being "the best".

It is important that the girls can recognize their own problems in the problems experienced by other apprentices, be they girls or boys. It must be important for girls as well as for boys that the teachers can tell them about similar problems they have had, and about different ways of solving them. This is one way of creating a fund of common experiences.

On this basis girls may be more prepared to accept challenges because it offers them a possibility to discuss what it is like to work with something new and how you can go about it.

Challenging the girls also means to expect something from them and to confront them with demands, not to give up when facing a problem but to try again.
We must not allow them to use their sex role by being "small and helpless".
We must not do things for them or allow that other apprentices (girls or boys) do things for them.
We must have confidence in their competence.

A pedagogy for girls include confronting the boys with other expectations and demands than they have so far been confronted with during the socialization process.

On a long term basis a new pedagogy at the technical schools means analyzing and changing the subjects, so that they pass on a different understanding of the concept of technology.

An understanding not reducing technology to an object, to a given thing, but conceiving of technology as a social process.
An understanding not interpreting "development" as a sort of a natural force with it´s own inherent power, unconceivable and indifferent to the will of human beings, as a power we must necessarily submit to in using it and controlling it.
An understanding interpreting "development" as a proces, resulting from human knowledge and human work.

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Notes

1) The technical schools are visited by all apprentices in Danish trade and industry during the time they serve their apprenticeship. Their basic training begins with a basic year in a technical schools in one of the following seven main trade areas:-"Iron & Metal", "Building & Construction", "Food", "Service", "Haulage", "Agriculture", "Graphic". After the basic year the apprentice must have a contract with a firm within a certain trade. In this second part of their education they return to school for further theoretical and practical education.

2) Two members of the group with solid experiences as teachers at technical schools, Grete Holm and Jane Olesen, have participated in the project in the entire period of it´s duration. Grete Holm has a university degree in comparative litterature, Jane Olesen in psychology. Grete Holm teaches apprentices computing. Computer scientist Susanne Hansen has been involved in planning the experimental teaching. Psychologist Kirsten Grønbæk Hansen has the main responsibility for the classromm observations.

3) It has already been established that certain subjects have the effect of maintaining and developing a polarization of the sexes. This has been done in Europe as well as in the USA. I shall mention two Scandinavian examples. Kari Garmannslund describes how the content and methodology of the subject of mathematics in Norwegian schools discriminate the girls in "Kan ikke jenter regne?" ("Are girls not fit for math?") Gyldendal Norsk Forlag 1983. Svein Lie & Svein Sjøberg describe how this is also true of physics in "Myke jenter i harde fag" ("Soft girls in hard subjects"), Universitetsforlaget Oslo 1984. Both published in Norway.

4) A Scandinavian example of research into this area is Kirsten Larsen & Harriet Bjerrum Nielsen: "Pigerne i klasseoffentligheden" ("The Girls in the public area of the class") in "Pigeliv" ("Girls´ life"), Emmeline 1981, Demark

5) see for example Evelyn Fox.Keller: "Reflections on Gender and Science", Yale University Press 1985.

6) The reports from the phases of the project are published by the Danish Ministry of Education, and can be sent to you by the Directorate of Education. Tlf. 01 925600.

7) Egebjerg Johansen: "EDB i dagligdagen" (Computing in everyday-life"), SYSTIME, Denmark

8) Such strategies are indeed being laid out by the state and the employers' organizations in Denmark, because it is predicted that women's unemployment will increase radically compared with mens' in the next five to ten years, while the iron industry will need qualified labour.

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WHAT CHOICE OF TECHNOLOGY FOR WOMEN?

INSTRAW

1. Scientific and technological advances are crucial elements of development and have resulted in the increase of jobs in fields linked to microprocessing, engineering and aerodynamics. However, such "improvements" can be both positive and detrimental to both men and women. In some countries, the number of jobs have increased as a result of technical change; in others, people can be displaced by automation, mechanization and computerization.

2. Research results from United Nations reports and studies during the Decade for women, indicate that the work load of women has actually increased in various sectors of the economy, more particularly in agriculture and household tasks. Surveys and statistics also show that several aspects of technological advances affecting women, result in loss of jobs, or, movement towards semi-skilled and unskilled occupations in the economic hierarchy. In industry, the repetitive and wearisome nature of jobs performed by women have become even more stressful and in some cases, hazardous to health.

3. In response to the fundamental problem of non-participation of women and girls in scientific and technological areas, the United Nations, in one of its conferences on "Science and Technology for Development", adopted a specific resolution on this subject in

Vienna, in August 1979[1]. This Conference called for the implementation of science and technology programmes through concerted action within the United Nations system as well as at the international and national levels, within the framework of the United Nations Decade for Women (1976-1985). The Conference singled out the inter-relationship between the scientific and technological advances and the development process, calling for increased participation of women in all scientific and technological endeavours. This resolution emphasized three specific areas of action: a) The equal distribution of the benefits of scientific and technological development and its application to men and women in society; b) The participation of women in the decision-making process related to science and technology, including planning and setting priorities for research and development, and, in the choice, acquisition, adaptation, innovation and application of science and technology for development; and c) the equal access for women and men to scientific and technological training and to respective professional careers.

4. Various United Nations bodies and agencies conducted surveys and undertook special studies to interlink women with technological change. Six years after the adoption of this resolution, in July 1985, the United Nations World Conference adopted the Nairobi Forward-looking Strategies for the Advancement of Women (FLS)[2]. Generally speaking, the FLS reaffirm the international concern regarding the status of women and provide a framework for renewed commitment by the international community to the advancement of women and the elimination of gender-based discrimination. The Conference specifically recommended the

increased participation of women in the research and implementation of science and technology, and in the evaluation of their impact on women and society when it urged that, "In the context of the Third United Nations Development Decade and any subsequent decade, the implications for women of international decisions specifically pertaining to international trade and finance, agriculture and technology transfer should be assessed by the United Nations system...." (Paragraph 351)[7].

INSTRAW (The United Nations International Research and Training Institute for the Advancement of Women) recalling the earlier initiatives of the Vienna and Nairobi Conferences, has developed a programme to analyze the choice and assessment of technology for the mobilization of women's participation in development. INSTRAW was created for the purpose of undertaking research and establishing training programmes to integrate and mobilize women as participants and beneficiaries in the development process, to raise awareness of women's issues worldwide, and to assist women to meet new challenges and directions.

6. One of the major programmes of INSTRAW is to prepare a global study, examining the issues in the broadest possible manner to cover various geographical regions. To date, three studies have been prepared. The first is a historical analysis of the emerging schools of thought on the impact of technological change on the

status of women throughout the world and takes into account the educational and employment structures, as well as the policies that may affect women's participation in scientific and technical fields. The second study reviews recent technological changes in developing countries, while the third analyses the impact of new technologies on the employment status of women.

7. Thus far, a review of current literature and statistics on the subject of women, science and technology, reveals that contrary to popular mythology, religious taboos, social customs, simple prejudice or bias, neither women nor men are inherently inclined towards a given skill or occupation. Unfortunately, however, these and other factors help perpetuate the belief that women are predisposed to non-scientific pursuits, limited in their career capabilities and unable to grasp abstract concepts.

8. Until about a decade ago, girls were obliged in school and at home to learn only those subjects that would eventually help them to become homemakers. Unfortunately, even today in many developed and developing countries, what academic training girls do receive is usually confined to the arts and humanities; although there is a movement towards teaching them technical subjects. Boys opt for more and more courses in science and technology. Earlier, most young girls were following segregated paths towards a job in the service sector which did not require specific skill or technical training. Most of these jobs are low-paid, requiring intensive labour which results in excessive fatigue. Labour laws and trade unions are rare and often do not protect this sector.

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9. These educational and social discrepancies set up a pattern of inequality which continues as women and men reach adulthood. Many well-trained young men find themselves qualified to accept positions in scientifically-demanding fields like medicine, microcomputers, industry and aerodynamics while their female counterparts labour as homemakers, subsistence farmers and assembly-line workers in industry. Subsequently men earn higher salaries than women who continue to perform largely low-wage or unremunerated tasks with their traditional, and limited, skills.

10. Research also shows that throughout their lives women, particularly those who are manual workers, find themselves displaced by machines which carry out simple, repetitive and time-consuming operations. Unfortunately, when this happens, enterprises may be unable or unwilling to retrain women in new technical skills which would ensure their continued employment and upgrade their skills. With new and emerging industries, many women workers are becoming victims of unemployment due to lack of training and qualifications. Then, loss of income, prestige and self-esteem are just a few of the devastating problems encountered by most women working in the organized sector of the economy.

11. Economic policies in some countries and the lack of women's participation in national mechanisms where scientific and technological decisions are taken, contribute to erroneous ideas and myths concerning perceived inadequacies and ignorance about the performance of women. For this reason, it is obvious that there are

fewer women in fields such as engineering, physics and hydrology. They also lack power to influence important decisions in areas such as irrigation, microcomputing, and electrification, which strengthen the infrastructure. Research, national funding and the allocation of resources is inadequate, in many countries, for women's actual needs and interests in scientific and technical training.

CONCLUSIONS

12. Clearly, technology and science, play a key role in the process of development. As a result, the discussion of women, science and technology issues have aquired considerable significance at the national level. National interest is of course subject to constraints which may be called "internalized" and which play a decisive role in perpetuating the existing division of labour within the economy and the household.

These constraints are directly and indirectly related to modes of production, the level of industrialization, land tenure systems and social traditions as outlined heretofore. These constraints -a complex package of economic and social factors- seem to create and perpetuate the "technological dependence" of women in relation to scientific initiatives, finance, technological control and skill formation.

Since "dependence" cannot be easily quantified, it may be suggested that the indirect cost of women's dependence on technology could be considerable in terms of unutilized of untapped human resources. In addition, this adversely affects the growth of

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productivity and employment. The slow rate of current development may have some direct relationship to the fact that inadequate attention has been paid to the participation of women in scientific and technological advancement.

Thus, it may be concluded that women's needs must be addressed through mainstream development efforts. Specific measures must be taken to ensure that women play an active role in major development projects and become involved in national and local development policy-making on an equal footing with men. In the long run this helps not only to enhance women's status as technological change occurs rapidly. It also contributes towards the economic and social progress of society and all its social groups.

FOOTNOTES

1. United Nations Conference on Science and Technology for Development, The Vienna Programme of Action on Science and Technology for Development (New York, UN 1979) p. 1.

2. The Nairobi Forward-Looking Strategies for the Advancement of Women. United Nations Department of Public Information Division for Economic and Social Information. 86-44198-April 1986.

3. Ibid.

Alternatives to School Curricula: Compensatory Co-educational Workshops.

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Mixed schools are relatively recent in Spain: they were introduced in 1970 when the General Education Act was passed. Until then, schools were segregated. Over the last five years, women sociologists and educators, worried by this new model which continues to segregate boys and girls, have begun to analyze mixed schools and their consequences. With the aim of improving on the present model, coeducation seminars have been created with the following main objectives:

a) Reform of the sexist model of school organization,

b) Designing of activities and promotion of situations which would allow a coeducation project to be put into practice,

c) Assessment of the work which the school or the group has carried out in this respect,

d) Giving publicity to the work carried out so that society and, in particular, men and women teachers can change their attitudes in their daily contact with boys and girls.

The proposal I am going to put forward arises precisely from this approach. It is a proposal which should be applied in schools from a very early age: if the process is postponed until a later stage in development the sexual role will already be established, and the chances of success fewer.

The current trends in pedagogical reform in Spain bear out the interest of educators and groups in establishing an active school model, as they are directly related to the concerns and changing mentality of our society. One category of this model is the workshop school. The following are some of the arguments in favour of this pedagogical model:

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a) development of creativity,
b) activity based on group role,
c) preparation of men and women for employment.

As an educator, a feminist and a member of one of these groups, I consider it of vital importance to develop this proposal in more specific terms in order to avoid the risk of it perpetuating the segregation of boys and girls.

My aim is to analyze which type of workshops offer a "compensatory alternative to the inequalities between the sexes" without losing sight of the model of society which we defend and the type of social relations which we aspire to create.

The activities carried out should be "useful" in the sense that they should avoid stereotyping and eliminate as far as possible the future sexual division of labour and segregation concerning careers guidance. It is our aim not only to deal with the method, but also to judge its effectiveness with regard to our ultimate aims.

Taking into account the firmly established division of roles and values in current society, we must consider three objectives:

a) To give the person greater personal and environmental independence. The elimination of discrimination regarding the limited models for living together and relations of dependence of men on women and vice versa would lead to greater satisfaction in interpersonal relations and would give us one of the micro-solutions to our demands for peace in our day-to-day lives.
b) Concerning the participation of women in the working world, we would aim to instill customs and provide training that would create a generation of active, concerned young women, capable of technical creativity.
c) Leisure resources. Learning to develop positive hobbies would prevent many young people from being destroyed by misuse of free time, with the frustrations this involves. This problem is greater for women since it is limited to personal fulfilment as a result of finding themselves in a working environment which

demands few qualifications and is a mere extension of the domestic role.

CONCERNING USE VALUES, NAMELY THE DOMESTIC ROLE, CARE AND CULTIVATION OF AFFECTIVE RELATIONS.

(Values which promote the integration of girls in society and which should be compensated in the education of boys.)

(1) In the research carried out in the classroom, we have found that quite a high proportion of boys reject these activities (2). They specifically reject activities such as sewing, cooking, hairdressing. They were seen to have already assimilated the attitude which considers everything "feminine" to be inferior. Other workshops dealing with care for others, tidiness, cleanliness, affection and sensitivity towards others must be seen as a means of personal fulfilment in addition to being a social function. These activities, which break new ground as far as affective behaviour is concerned, dolls, psychomotor development and drama, would help to eliminate concepts such as: virility as a synonym for combat, toughness, aggressivity; femininity as quite the opposite. Making boys tough and girls soft and weak is the same as saying boy equals "combat role", girl equals "victim role".

CONCERNING EXCHANGE VALUES OR PRODUCTIVE ROLES.

(Values which promote the integration of boys in society and which should be compensated in the education of girls.)

No school intended to prepare boys and girls for employment can be conceived without school workshops, which develop very clear working habits and further the pupils'general education (3). In order to develop these attitudes, activities with an active methodology and involving research must be introduced in schools. This would involve a choice of workshops dealing with different trades - working with wood, textiles, do-it-yourself, model aeroplane building, printing, drawing, design, agriculture (school farm, school garden), all of this complemented by research into the environment concerned...

Jobs involving technical responsibility are normally entrusted to men, regardless of their professional qualifications, although

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they, in any case, have more possibilities for specialization and promotion.

For this reason, in general women go to work less prepared than men. The arguments put forward by management in this respect are that women are incapable of doing anything different since they don't understand mechanical things. Opinions of this type reflect the belief in the stereotype of what is "natural" in women and in the naturalist concept of inherited disadvantage (4).

As has been shown in research carried out to date, women's lack of ability in certain jobs is due to lack of experience and training for them (5).

In this type of workshop we have seen that girls, apart from showing considerable interest, are very creative and show no signs of rejecting this type of activity (6).

It is obvious that it is easier for women to train for jobs that have traditionally been entrusted to men than vice versa. If no compensatory teaching is offered, women will continue to be excluded from technological sectors of professional training and university courses; this means that opportunities for training in these fields must be offered from a very early age, in my opinion from 0 - 6 years, in order to counteract the strong influence exerted by society.

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Finally, with regard to the analysis of use values, our idea is not for men and women to share all present domestic tasks, since, in order to achieve a better quality of life, it is necessary to persist in demands regarding state participation in many domestic tasks (such as school dining halls, crèches with flexible timetables, homehelps to look after children etc.).

(Translation: Dorothy Kelly
Anne Martin)

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WOMEN IN SCIENCE AND TECHNOLOGY - PROBLEMS AND PROSPECTS IN KENYA

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SUMMARY.

The objective of this study was twofold: First it was to analyze the factors and problems Kenyan women face in science and technology; secondly it was to explore the possible prospects that would enable more women to enter the scientific and technological fields.

The role of women in development has now been recognized in Kenya as women are known to be the backbone of national prosperity. The introduction of advanced technologies and modern scientific innovations was certainly a sound policy and a key to change, although the manner in which it was done especially with regard to women, has introduced a number of problems. When new technological innovation was being introduced, women were usually ignored. Consequently, women have had limited access to information and to educational and professional opportunities in scientific fields. Curriculum options in educational institutions reveals that most of the places available for women are in the humanities. Furthermore, because of their low educational attainment, and low rates of participation in the modern sector, women have been largely excluded from the process of decision-making and formulation of policies. Cultural resistance to women's involvement in scientific fields have also hampered their benefiting from technological developments.

It is hopeful that Kenyan women have formed groups and are already involved in food processing, afforestation, water projects and other programmes that utilize modern scientific and technological innovations. There is increased involvement of women in scientific and technological activities at managerial, policy and field levels.

1. Introduction:

The role of women in development has now been recognized in Kenya as being of a fundamental significance. It is realized that the women of Kenya are the backbone of national prosperity.[3] Women are, therefore, no longer considered as only marginal to the scientific and technological development process; instead, they are regarded as essential human resources. The introduction of advanced technologies and modern scientific innovations was a sound policy and a key to change, but the introduction was not done in the context of the cultural and socio-economic environment in which these technologies were to operate.[4] Hence, the impact has not been sufficiently far reaching.

The reasons for the ambivalent impact of modern science and technology in the Kenyan context can be traced back to the historical patterns of modern technology in our country. No attempts had been made to understand how imported technology would be assimilated and change to suit local conditions, nor was any consideration given to how technological improvements of various kinds were brought about. Women, who are mainly the end-users, were usually ignored and consequently had limited access to information as well as educational and professional opportunities in scientific fields.

Furthermore, the scientific innovations and technologies themselves were often proved unsuited to local resources and objectives and often operated in an inefficient way. One reason for this inefficiency was that women had not mastered the technological phase of skills, knowledge, facilities, and organizations upon which further technical progress so largely depends.[1] Curriculum options in educational institutions revealed that most of the places available for women were in humanities.[2]

Women in Kenya are largely involved in marketing, food production and processing, as well as consumption and population growth. However, women have been largely excluded from the planning process, decision-making and formulation of policies. Women are known to carry out what other people, mostly men, have decided, and for whom most women's labour, in economic terms, is invisible. Cultural resistance arising from views longheld about the role of women in society also hampered their benefiting from technological developments.

During the International Symposium on Science and Technology for Development, in Singapore, 1979, the group on education and training was strongly convinced that education and training, with special reference to learning, play a vital role in the process of applying science and technology to developing countries. Further, the group noted that the absence of the necessary educational base in a country hinders the most effective use of modern science and technology for development.

In education, the group identified the following as urgent and priority needs: literacy programmes, adult education programmes, training of teachers, training of technicians and education of women.[3]

It has become increasingly apparent that, to ensure that every woman becomes aware of the role of science and technology, the development perspective must be interwoven into women's education at all levels. This would make it possible for women to comprehend more readily the situation in their own homes and, at the same time, make them more receptive to the possibilities of using science and technology for increased production.

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women in science and technology must, therefore, be seen in the overall context of women's educational trends and their participation in wage labour employment.

2. Educational Trends.

Sex differences in educational attainment in Kenya have diminished as the educational system has expanded since independence. During the early colonial period, when little provision was made for educational facilities for Africans, men and women shared this deprivation relatively evenly, whereas the increased availability of schooling on the eve of independence disproportionately favoured male prospects. The post-independence movement toward universal primary education in Kenya has reduced the differences between the sexes with regard to opportunities for primary education.[10]

At the secondary school level, available records and statistics show that, most of the places available to girls are in the humanities, whereas boys have proportionately greater access to schools offering courses in sciences. For instance, in 1976 there were a total of 26 art streams and 13 science streams in comparison with 28 art streams and 64 science streams in boys' schools (Table 1). This distribution of places provided an incentive for women to specialize in arts in Form IV in order to imrpove chances for admission in upper secondary (Form V & VI) and helped to reinforce the emphasis on humanities in girls' schools. The absence of strong science programmes in most girls' secondary schools results in a female output predominantly in the humanities at the time when career training programmes and university requirements favour those with science and mathematics specialization.

There has been little change in the proportion of female enrolment in the science-based faculties of the University of Nairobi (the first and major University in Kenya) since its founding . (Table 2).

Table 1:

Number of Fifth Form Science & Arts Streams Available in 1976.

Type of School	Arts Streams	Science Streams
Girls Boarding Schools	22	11
Girls Day Schools	4	2
TOTAL	26	13
Boys Boarding Schools	27	62
Boys Day School	1	2
TOTAL	28	64

Type of School	Arts Streams	Science Streams
Mixed Boarding Schools	2	11
Mixed Day Schools	10	11
TOTAL	12	22

Source: Central Bureau of Statistics.[10]

On the grounds of the data gathered and presented in Table 2, the following irregularities have been observed:-

- The Disparity between men's and women's enrolment in the Sciences is apparent.
- There has been little change in the proportion of female enrolment in the science-based faculties.
- Women are under-represented in the science-based faculties.

Female representation in other post-secondary science-based institutions and programmes is very low. Kenya Science Teachers' College, which, as the name implies, trains non-graduate secondary school science teachers, has had 20-25 percent female enrolments. At the Kenya Polytechnic, female enrolment was 16 percent in 1977.

The foregoing brief analysis on educational trends shows that women are under-represented in sciences in educational institutions. Among the known factors that discourage young women from pursuing scientifically based curricular or careers include; sex-role stereotyping, teaching staff and methods of teaching, attitudinal factors, socio-cultural factors, career aspirations and self-concept.[2] Other factors include values, school performance, female isolation in sciences and social implications of science.

3. Participation in Wage Labour Employment:

Female representation in modern sector wage labour employment has remained low, despite a rising trend. The percentage of women in total modern sector wage employment was 12.2 in 1964, rising to 14.8 in 1972, 16.8 in 1976 and 18.0 in 1981.[6] Although Kenyan women are increasingly entering fields that have been traditionally dominated by men, they are still under-represented in many areas including natural sciences. Statistics from labour force participation show that in 1978, women comprised only a small percentage of the workforce in all scientific and technical areas. As a result, women's earning power and job opportunities as a

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Table 2

Number of Undergraduate Students in the Science Based Faculties of the University of Nairobi
1970 - 1970

Academic Year	Kenyans		Tanzanians		Ugandans		Others		Totals		Grand Totals
	M	F	M	F	M	F	M	F	M	F	M + F
1970/71	1062	136	171	5	184	6	61	8	1478	155	1633
1971/72	1038	142	190	4	158	1	110	17	1496	164	1660
1972/73	1035	138	173	6	173	5	54	11	1435	160	1595
1973/74	1261	149	159	3	134	4	46	6	1600	162	1762
1974/75	1410	167	148	1	117	3	44	9	1719	180	1899
1975/76	1469	186	104	15	69	5	58	17	1700	223	1923
1976/77	1667	232	66	1	36	3	104	31	1873	267	2140
1977/78	1881	276	35	-	18	-	88	18	2022	294	2316
1978/79	2221	432	15	-	10	3	58	39	2304	474	2778
1979/80	2396	449	11	-	2	-	102	39	2511	488	2999
TOTALS	15440	2307	1072	35	901	30	725	195	18138	1267	20705
% By Country and sex	74.57%	11.14%	5.17%	0.16%	4.35%	0.14%	3.54	0.94	87.6%	12.39%	100%
Country Totals	17,747		1,107		931		920		20,705		20,705

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group are diminished. Another effect is a loss of talent in the labour force which needs women scientists and technicians to help solve social problems and improve the quality of life.

Women tend to be concentrated in certain occupational groups and under-represented in others (Table 3). The nature of women's participation differs in the public and private sectors (Table 3).

Table 3:

Sex Distribution of Wage Employment of Kenya Citizens by Occupational Sector, 1976.

Occupation	Public Sector		Private Sector	
	No. of Males	No. Of Females	No. of Males	No. of Females
Unskilled Workers	120,332	11,574	23,777	35,518
Skilled manual Workers	31,376	5,153	49,832	1,988
Technicians & Supervisors	6,180	295	5,258	325
Architects, Engineers & Surveyors	884	5	488	9
Medical, Dental & Veterinary	1,646	1,523	117	144
Agronomists	330	21	37	0
Statisticians & Mathematicians	126	6	50	16
Other Scientists	341	28	42	3
Accountants	248	7	374	18
TOTAL	162,073	18,572	80,280	37,999

Source: Central Bureau of Statistics, 1978[10].

Women's low rates of participation in the modern sector result from a number of factors. Women's primary obligation is to farm the family holdings and produce food for family consumption. This widespread involvement of women in farming reduces the numbers available for other forms of economic activity. Women's low rates of literacy and educational attainment place them at a disadvantage in seeking employment, and thus have limited possibilities of getting influential positions in the society. It is also more difficult for women to reconcile family obligations, particularly child-rearing, with the fixed hours and work schedules demanded by most types of wage employment as compared with farming on the family holdings.[10]

Despite the low rates of female participation in wage employment, women in Kenya work very hard. The vast majority of Kenyan women, some 88% of whom reside in rural areas, are economically active. According to the 1977/78 labour force survey, 87% of the entire adult female population reported as being employed in unpaid family work, part-time labour, and part-time farming on family holdings.[10]

The foregoing analysis is of importance with respect to its implicatations for Kenya's national development policy. A comprehensive development programme needs to incorporate prospects for improving the quality of women's lives. This implies reducing their workloads as well as increasing their production through modern scientific innovations and appropriate technology.

4. Scientific and Technological Prospects for Women.

> "... Technology is human knowledge applied to human needs. It is not gender-related, but affects all people and all needs, from the most humble to the most sophisticated. Social and economic development cannot be successful without the participation of women, who make up more than half of human kind. All elements of society must be involved in the choice of science and technology for development; all must understand its limitations and all must enjoy its benefits."[3]

Kenya is making attempts to promote appropriate measures to remove obstacles and provide incentives for the incorporation of the female members of the population in scientific and technological education and careers with the aim of affecting a significant increase in the stock of women scientists, engineers, managers and technicians. The aim in adult education and extension programmes is to increase the general scientific and technological literacy of women particularly in rural areas so that they can benefit from science and technological development.

The Development Plan of 1984-88 is directed towards the establishing of a just and equitable social order. This requires in general, structural transformations allowing for the participation of all sectors of the population in the benefits of science and technology.

The government, through the District Focus for Rural Development, has as its major aim, elimination of the dichotomy of demands that may exist. The urban women elites have consumption patterns similar to those in highly developed countries, while, in contrast, the mass of the population of rural women does not participate in the same market for lack of purchasing power or lack of access to modern technology.

Despite the social and cultural constraints, wome women have managed to enter the scientific and technological fields. Girls in the schools have derived inspiration for non-traditional education from their parents, who themselves are part of the small percentage in non-traditional careers. In 1986, the prestigious Kenya National Academy of Science with 33 members had one woman.

The education system in Kenya has undergone major changes. Girls have received improved opportunities and greater encouragement to participate fully in science and technology education. As more and more girls' schools provide science streams, more girls begin to be enthusiastic, creative and responsive. Girls' schools are beginning to feature prominently in the yearly Kenya National Students' Science Congress.

The curriculum is being revised to include courses in theory of science, with pointers on the relationship between science, technology and society. Examples that make science subjects relevant to everyday life are being emphasized in some upper secondary courses, such as Science in the Home. In educational institutions, girls and boys alike participate in wood work, metal work as well as home science and appropriate technology.

Women have been appointed in key positions that will influence support for research on different topics. Practical research to identify social and cultural factors, which may be limiting access of women to scientific, technological and managerial careers, are getting priority. There is a growing emphasis on research to develop labour-saving, production enhancing technologies for women's provisioning activities, especially the production processing and preservation of food.

Adult education programmes geared towards increasing the awareness and full participation of women in the modern world of science and technology have assisted Kenyan women in developing a sense of personal worth and pride which was previously lacking.

There are over 14,000 different women groups in Kenya.[1] The scope of their development activities encompass such widely differing areas as food processing, afforestation, water development, and small scale home-industries that utilize modern scientific and technological innovations. Small scale industries suitable for small towns and communities have enabled some amount of self-sufficiency and has in turn raised the quality of life in many households.

There is a slow but steady increased involvement of women in scientific fields and in appropriate technology at managerial, policy and field levels. In 1986, more than 15 Kenyan women were appointed to top managerial positions in industrial and commercial corporations in the country. More and more women are involved in appropriate technology programmes that make their labours much more productive and more rewarding and will thus improve their lives and those of their families. In this way they are able to contribute significantly to the society and the economy.

With trends in urbanization and scientific innovations, women not only procreate, but also go to school and participate in other national development programmes. Women are aware of the fact that their role in scientific and technological fields will depend on training and participation. The stereotyped concept in the traditional society that women's place is in the kitchen is gradually disappearing as more women enter full time employment.

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Manpower management, sexual division of labor and technological change in the banking sector

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On the basis of a research on the banking sector in France and Canada, I would like to put into light the role of manpower management in the sexual division of labor, in a context of technological change.

First, I would like to make it clear that I do not consider manpower management to be exclusively responsible for the sexual division of labor. However, my research tends to show that it is an important factor in explaining the sexual division of labor, as well as the social division of technology or techniques which is associated to it.

Of course girls' socialization as well as the design or conception of techniques themselves are partly responsible for the sexual division of labor, as many other researchers have shown, but my research sheds light on another factor, often neglected, which not only has a strong impact on the sexual division of labor, but may also be retroactive on socialization and the conception of technology, although I have not done enough research to conclude on this last aspect.

In other words, the way in which companies use womens' traditional place and function in the family, whether a specific woman is in such a situation or not, to differentiate their human resources policies according to sex, particularly in terms of recognition of qualifications, of access to the "internal labor market", of promotion and career lines, is an important factor in explaining the sexual division of labor.

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In a context of technological change, as well as in a context of deregulation as is underway in the financial sector, the employment system (job entry ports, occupational career lines, etc.) is being destructured and remodeled. Criteria, rules and various characteristics of the internal labor market are touched, some being destroyed and replaced by new rules or criteria. All employment parameters are not destroyed instantly, but many traditional characteristics of the employment system are modified. In the banking sector, reorganization is largely based on more formal knowledge, stronger technical qualifications, as well as more commercial (sales) capacities.

In our view, the acquisition of these new qualities represents a more violent process in North America (Canada) than in Europe (France) because the latter values "socialized adjustments" to change, whereas anglo-saxon systems do not manifest such a tendency or preoccupation for social impact.

Given these different attitudes toward change, whether it be technological change or institutional changes such as deregulation, firms still do have a choice to make in terms of manpower management. Various strategies are open to them, and these strategies will have an impact on female labor, the women present in the firms as well as those who could eventually enter the labor market.

Manpower management strategies

My analysis of employers' strategies in the banking sector leads me to consider two main categories. The first is a strategy which can be called "flexibilization" of the employment system. It rests on the development of particular or non typical forms of employment in terms of employment guarantees (short duration contracts, occasional work, etc.) or of working hours (part time), as well as on wage adjustments, such as the reduction or elimination of cost-of-living adjustments. The banking sector usually uses the two first methods of flexibilization, wage adjustments in COLA clauses being more common in manufacturing sectors (automobile, steel, etc.).

The second strategy is one which aims at workers' participation, their motivation and involvement in the firm. This usually means more occupational training, more "democratic" work organization, development of a strong "internal labor market" and so on.

It is not at all impossible for a firm to use both strategies, either simultaneously in one place, or in different establishments. It is even common to use different strategies for different occupational groups, and maybe even more so for different sex categories. In the banking sector, it is particularly evident, since the internal labor market (career lines based on training, etc.) is very developed, but not very open to women, who are generally restricted to"entry port jobs".

However, both strategies are very different in terms of methods and of impact on the labor force. The first is a strategy of pure rationalization, of cost minimization through direct or indirect wage compressions, or through close adjustment of working hours to the volume of production in order to ensure higher productivity of work.

The second is a more qualitative strategy, the development of new products and services and the involvement of workers in the firm's project, or their identification to the firm's "culture" as many now say, being considered determinant for productivity.

Many researchers consider the first strategy as a more

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traditional or defensive strategy, whereas the second could be qualified as *modern and offensive*. Research done in Norway (E. Kvande, B. Rasmussen) concludes to the existence of two types of organizations, which very closely resemble our own classification, from a slightly different point of view: *static* and *dynamic* organizations.

The static organization has a strong hierarchy, with bosses making all the decisions and a strong division of labor. The dynamic organization has a more decentralized structure, with team work and tasks less strictly defined, sometimes varying over time. Will anyone be surprised to learn that the dynamic organizations are more open to women, in the sense that they are the ones who offer them access to interesting careers, access to the internal labor market? Of course the vast majority of women remain in the traditional, defensive and static type of organizations, as can be judged by their position in the labor market in general, as well as in the banking sector.

Banks' management strategies

My interviews and research in the banking sector in France and Canada (Tremblay, 1986) indicate clearly that there exists a very developed internal labor market in this sector. As Doeringer and Piore (1971) have defined this concept, we have used it to define the very developed system of job training in banks, the relatively clear lines of promotion, the rules and conventions, or branch agreements, that organize the allocation of work, the strong hierarchy of jobs, and finally the very recent branch agreement on technological change in French banks. It must however be noted that the lines of promotion or careers are clearly more open to men than to women, in Canada as well as in France.

There are however important differences between the two countries' attitude towards redundancies in the labor market, and this has an impact on banks' strategies toward labor in general, and female labor in particular, in the context of technological change.

In Canada, part-time work is developing very strongly, as is the case in the USA, and female employees are clearly more concerned than their male colleagues(CSN, 1983; Pinard, 1985).

On the contrary, in France, part-time work is very marginal, but it is developing for female bank employees (3 to 5 % of the labor force). In this perspective, it can be said that French banks have preserved the "normal" form of employment (i.e. full time, indeterminate contract). We also observed a certain interest for employees' participation and involvement in the "firm's project", modern management forms and occupational training. This interest is slowly developing in Canadian banks, but the concern for the "firm's culture" seems much stronger in Europe than in America in general, and Canada in particular.

How do these factors impact on women's participation in the labor force, particularly in the jobs of tomorrow, those more qualified in terms of technological or specialized knowledge? In the banking sector, it is clear that the need for non qualified employees, not to say women, has diminished radically, while specialists, particularly computer science specialists, are in strong demand. Obviously, no bank will be able to turn employees into high tech specialists. The best actual women employees can look forward to is the opening of the internal labor market to women, the offer of occupational training which could lead them to specialized (but not technical) jobs, such as commercial and sales activities. As many have observed, banking activities are more and more a question of selling

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financial products. From the point of view of manpower management, this leads to two strategies. As concerns the technical jobs, the strategy is clearly one of hiring new employees; this leaves a possibility for women's participation to increase, but few believe it can be done in the absence of a definite strategy aimed at such an objective.

As for more commercial jobs, there can either be firings and hiring of new employees, or internal job training and mobility, which would permit women employees' access to ascendant career lines.

The issue of undergoing changes is still unclear in Canada as well as in France, but a few recent experiences do indicate that it is largely a question of choice of a given management strategy.

Let us mention the case of three French banks which have adopted specific programs in favor of the equality of women in employment (Laufer, 1984). These experiences are too recent, and too limited in scope, for us to conclude, but the results will be interesting to analyze in two or three years from now. Let us not forget that the vast majority of bank employees are women, but the higher you climb in the occupational hierarchy, the less women there are.

For the moment, the results of a study on the "demand" of women for such potentially ascendant career lines are interesting to study, since very few studies, to our knowledge, have addressed this question.

The study revealed that among bank employees, 50 % were not satisfied with their employment situation. Amongst them, 10 % were said to be "naturally career-minded", another 10 % were "involuntarily blocked" (object of discrimination), while some 30 % were vaguely interested in equality of opporunity for women, but more interested in a work organization less strictly defined, different work schedules, etc.(Laufer, 1984). Socio-institutional factors are of course at work here (sexual division of labor inside the family, day care, opening hours of stores, etc.); the situation can therefore evolve, and is surely different from one generation or one country to another.

Nevertheless, to give a positive note, it could be noted that some firms have started developing a strategy for using what they see as "women's unexploited potential". These firms recognize the fact that women are no longer "just passing by" on the labor market; they realize that women are there to stay, but that they have often been the object of discrimination.

In this perspective, they may consider it advantageous to exploit the potential of women whom they consider to have been the object of discrimination. On the contrary, they sometimes consider that men who haven't managed to climb the promotional file just don't have the qualities needed (Maruani, 1985).

This last strategy is of course not dominant, but it may reveal a new trend and it surely shows that employers' strategies in terms of manpower management have a strong impact on women's participation in various occupational categories, particularly the more technical ones which become more and more dominant in all sectors. While being in the service sector might have protected women from the impact of the last crisis, at least to some degree, it is not at all sure that their jobs will be protected throughout the technological changes underway.

Considering the impact of manpower management on the sexual division of labor, on the participation of women in various occupational categories, management strategies aiming at increasing the participation of women in technology, as well as improving the quality of their participation in technical jobs as well as technology in general, would surely have a positive impact.

In fact, not only would they change the quantity of women involved in technical jobs, but they would most probably change the attitude of girls and women towards technology. It seems clear that the type of work to which women are restricted because of a differentiation of manpower management according to sex, the occupational categories which are open or closed to them, contribute to shape women's attitude towards technology.

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DON'T ADJUST THE SET
THERE IS SOMETHING WRONG WITH THE PROGRAM

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Instead of asking the question "What is it about girls that they do not tend to study math?", I believe that the more relevant question is "What is it about math that girls tend not to study it?"

Girls are the most visible "drop-outs" from math. There are however, other groups with similar patterns of participation and performance. When we look more closely at these then we see that it is not girls who need to adjust so much as the math program itself that needs to change.

Rayna Green's study "Math Avoidance: A Barrier to American Indian Science Education and Science Careers (Education Research Bulletin v.6 no.3 p. 1-8 Sep 1978) found that math anxiety and math avoidance were the most serious obstacles to general education and to the choice of scientific careers. Native American students interviewed in the study generally disliked math; there was a missing or negative impression of the math capabilities of Native Americans; a generally negative image of mathematicians and scientists; a feeling that math was irrelevant to their lives; that math courses and requirements were too rigid; and a self-perception often fostered by school counsellors of hopeless inadequacy in math skills.

The study found that some successful attempts at math instruction for Native American students involved a supportive atmosphere for math learning; individualized non-competitive programs, tutorials, math anxiety clinics, exposure to Native American role models, courses with an applied focus directly related to a career or community need and early math skills developed on everyday examples.

In New South Wales (NSW) Australia's most populous State there was between 1982 and 1985 a marked increase in the proportion of girls studying 4-unit math, the most demanding math course for our 17 and 18 year olds. The proportion of students who were girls changed from 19.9% to 28.8%. To achieve that kind of change meant that there would have been a 50% increase in the numbers of girls taking 4-unit math, achieved in just 3 years.

The explanations given by the NSW Education Department included the introduction in 1979 of a non-sexist education policy; programs that brought successful women engineers and architects into schools to talk to girls about careers in those areas; changes to curriculum materials and the ways in which the subject is taught with teachers being encouraged to spend more time with individual students.

There is no reason why any student should be forced to learn in anything other than a supportive atmosphere, with individual attention, positive role models and an explanation of the relevance of what is being taught. However in math particularly any other kind of environment is quite harmful.

Math at primary school has in the past tended to emphasise an automatic response to fairly limited concepts. At secondary school and beyond a more considered response is required on more complex concepts.

Biggs (Information and Human Learning, Cassell Australia 1968) has labelled the rapid response to a limited concept "narrow coding". It is akin to rote learning. The response to wider concepts is termed "broad coding" and is related to understanding structures. Narrow coding is facilitated by anxiety which focusses the mind on a limited concept but "broad coding" is disrupted by anxiety which distracts the thinker from covering the breadth of a wider concept. The facilitation of low level skills through anxiety has been proven biologically (Schacter, S. and Singer, J.E. "Cognitive Social and Psychological Determinants of Emotional States" Psych. Review Vol 69 p 379-399, 1962).

Girls and women tend to have higher levels of anxiety than boys and men (Maccoby,E.E. and Jacklin,C.N. "Sex differences in Intellectual Functioning, Assessment in a Pluralist Society" Proceedings of the 1972 International Conference on Testing Problems, New Jersey E.T.S. 1972). This arises mainly from cultural factors associated with the fact that it

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is a male-dominated society. The degree to which a person feels in control of a situation affects their level of anxiety.

Based on the results of a study of 4,000 ten year-old British Students, Biggs ("Mathematics and the Conditions of Learning" N.F.E.R. London 1967) argued that the superiority of girls was at narrow coding which is facilitated by anxiety and this gave them an advantage at mechanical arithmetic but in broad coding boys would have superiority and this would emerge at secondary school.

Anxiety may lead to a situation where even greater reliance is placed on the previously "safe" rote learning methods. This in turn leads to lowered performance in tests demanding the understanding of broad structures. Lowered performance leads to greater anxiety and a feed-back system is set up between anxiety and lower performance which effectively hinders further math learning of a conceptual nature.

Just as it is a male-dominated world, it is also a world dominated by people from upper socio-economic levels. Anxiety is also stronger among males from lower socio-economic groups. Biggs (Anxiety, Motivation and Primary School Mathematics, N.F.E.R. Occasional Publication No 7 1962) found that for those areas of elementary math dependent on computational skills which are more likely to be facilitated by high levels of anxiety, "abnormally" high performance was recorded for intelligent pupils of low socio-economic background, both boys and girls. They did not however perform well on broad coding skills. The mechanism of using rote learning long after this was inappropriate was favoured by boys from low socio-economic backgrounds as well as by girls. These findings are supported by the work of others (reviewed in Widdup, D. Review of Research on Sex Differences in Mathematics, a paper for the S.A. Government Women's Advisor's Conference 1980)

Biggs (1967, op. cit.) suggests that math is unique amongst school subjects in the extent to which failure is associated with fear and anxiety. The very preciseness of math is such that the individual quickly becomes aware of a misunderstanding, whereas in other subjects there is more freedom in which to interpret data.

What happens to the bright conscientious rote-learner of math? Well, in Australia many of them became junior primary school teachers, taking their math anxiety back into the classrooms. In Australia there is evidence that junior primary school teachers with math anxiety were finding ways of avoiding teaching math at all. Those that did teach it often went back to the rote methods that had been successful for them in junior primary. A relatively unchanged curriculum fostered this process.

Some exciting work to counter this is taking place in parts of Australia. Helen Pengelly co-ordinated aprogram in South Australia in 1985 which enabled a number of teachers to be

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released from teaching in order to have their confidence in their math ability restored and also to develop new ways of teaching math. They have then gone back into the schools to help their colleagues. The program is concentrating on schools where there are disadvantaged children. The work is exciting because the math concepts the children learn are far more sophisticated than the ones they have previously been taught. And this is the important part: it is the children who are learning with the teachers helping but not imposing the artificial strategy of learning by rote. Concrete materials are used and the children learn by the recognition of patterns and by concrete games.

In "Mathematics Making Sense" (photocopied paper) Pengelly writes of the new classroom atmosphere:

> "One day a child responded to a 'why' question from her teacher with a puzzled grin 'Yeah! I don't know that yet' Although she obviously felt comfortable not knowing, it became the catalyst in the struggle to know. All children are naturally curious. We must foster this curiosityby providing an educational climate that does not inhibit investigation. A teacher's task is not to give answers but to support children arriving at their own answers."

The answer is not just in the use of concrete materials. Pengelly is critical of the use of concrete materials that still encourage rote responses. One curriculum resource she cites suggests:

> "Put three blue beads in a tray. Put out one red bead. Move the red bead into the tray to join the three blue beads. Say three and one more."

Pengelly sees this experience as prescribing what to do, when to do it and how. This may not be teaching the child anything about addition, only about following instructions and second-guessing what the teacher wants. She says that:

> "We need to create for children a mathematically significant environment which will arouse their curiosity and imagination and provoke within them a desire to find the order, the patterns and the relationships that exist between and amongst objects and events within our environment"

The work of Pengelly and others involved in the early childhood revolution in math teaching in Australia has been going only a couple of years. The children who have been involved in the program are now moving through the primary school system creating demands for more imaginative teaching. The method encourages the natural learning strategy of discovery involving concrete materials and situations and couples it with the rigour of recording results and interpreting these. There is far more of the discipline and creativity of math in this approach than in rote learning and it will be interesting to see how the children, particularly the girls and bright boys from lower socio-economic backgrounds develop. My own feeling is that it will be for the better both for the students and the teachers.

Reviews of sex differences in math (e.g. Widdup 1980 op cit.) have consistently shown that the intellectual abilities of the sexes are essentially the same. Consistently reported sex differences in spatial ability are relatively minor, are arguably environmentally caused and have questionable relevance to math ability. Sex differences in math ability that have been reported have tended to rely on studies of males and females with very different math backgrounds; comparing a group with liitle previous math (women) with a group with more math training (men) and not surprisingly finding differences in assessed ability between the two groups. When previous math training has been held constant sex differences in assessed ability have largely disappeared. In addition biases in some tests disadvantaging women have been reported as giving rise to reported sex differences.

We are aware through these same reviews that there are women who are not disadvantaged. Middle socio-economic background girls in high socio-economic schools are the highest achievers in Australian schools. Other high achieving women come from all-girl families, daughters of happy career women, women from cultures valuing female achievement. We know that confidence and encouragement play a large part in the achievement of women.

BEYOND THE STAR TREK SYNDROME TO AN EGALITARIAN FUTURE WHERE NO ONE HAS GONE BEFORE

Leslie R. Wolfe and Jennifer Tucker

Project on Equal Education Rights, NOW LDEF

On the bridge of the Starship Enterprise, Captain James T. Kirk presides over a carefully integrated crew -- a 1960s flawed vision of the future that appears to be a model of racial justice and sex equity. Along with talking computers and warp speed travel, the Enterprise goes "where no man has gone before" in portraying the society of the 23rd century. But this Star Trek future retains the race and sex stratified social structure of the 1950s, which we will describe later in this paper. First, we would like to share with you some stories from today's equity frontier, to exemplify the impact of sex bias and to help explain young women's continuing pattern of unequal access and apparent "disinterest" in science and technology:

*A superintendent in a midwestern school district, discussing the acquisition of computers for the junior high school, indicated that first priority for computer learning would be given to the boys, because they would "need to know about computers for their future careers, in engineering."

*A superintendent in a major urban school district in the east responded to charges of sex segregation in the district's extensive computer education programs by declaring that there was NO problem at all, because almost all of the students in word processing courses were female.

*Another school offered elective courses in both "Keyboarding" and "Personal Typing." Keyboarding was designed for the "boys who were going to be taking programming and

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couldn't type," while "Personal Typing" was a course for girls preparing for clerical jobs.

*A computer-using elementary school teacher who had received equity training reported that one of her young students kept refusing to take her turn on the computer. After several minutes of gentle but persistent questioning by the teacher, the girl admitted that she really wanted to work on the computer, but "the boys had said if she didn't give them her turn, they would hit her."

*A frustrated parent reported to PEER that her daughter's eighth grade math teacher reassured the parents about their child's lack of interest in math by saying: "Oh, she's such a pretty little thing. She'll get married at eighteen and won't need to know much math."

In addition to such direct messages, internal psychological barriers -- absorbed from the sex and race stereotypes expressed by peers, teachers, textbooks, TV, and family -- often discourage young women from pursuing math, science and computer learning and scientific or technical careers. Is it any wonder that, by the time they reach junior high school, many girls already have decided that math and computers are "not for me" or that they "aren't good at computers," or that their future jobs will not require technological literacy? Just as their mothers learned "math anxiety and avoidance," so many of today's girls and young women have learned "computer anxiety" and "technology avoidance." Young women of color are doubly discouraged by the long term effects of combined race and sex stereotyped assumptions.

In 1962, Robert O'Hara reported, in The Roots of Careers, that "by the time they are in the fourth grade, girls' visions of occupations open to them are limited to four: teacher, nurse, secretary, or mother." Twenty-three years later, in 1985, a career consultant reported to PEER that: "In one of the workshops I conducted, I was talking to an audience of young high school women about opportunities in technology and I asked how many thought they could be anything they wanted to be. Four girls out of 45 raised their hands."

A recent study by Kahle and Lakes found that a majority of 13 and 17 year old girls report that science classes -- especially those in the physical sciences -- are "boring and make them feel stupid." These same young women think that science is not "relevant" to their daily lives. It is little wonder that the discrepancies in science achievement betweeen boys and girls in physical science are, by age 13, greater than the discrepancies in any other area of science.

By the time they reach junior high school, many girls have learned to think of technology as one 12 year old did; when asked what she would use her computer for, a 12 year old girl said "I would ask my computer to find me a perfect husband. I would tell it to tell me where to find the prettiest clothes and tell me where to get my hair done." Another group of fourth through twelfth graders were asked what they saw themselves doing with the computer at age 30. The girls said "housework" and the boys said "finances, data processing, and games."

We are deeply concerned that our young women are learning to undervalue their own capabilities, limit their career and life options, and devalue themselves as people. Recent evidence from a survey of female and male high school valedictorians and honor students reveals that young women's estimates of their own abilities were significantly lower than men's after less than two years in college, despite the women's higher grades.

The survey found that 23 percent of the men and 21 percent of the women had rated themselves as "far above average" in intelligence when they were high school seniors. But by the time they had reached their sophomore year, 22 percent of the men still graded themselves that highly; but only 4 percent of the women did.

All of these anecdotes reflect something of the equity problems that persist in computer education today. With more than forty thousand computers in the schools for more than forty-two million students, questions of access and function still must be asked: how will we decide who has the opportunity to use computers? Who will learn programming? Who will learn applications? And who will have the authority to make these decisions?

As educators, we must take the lead in envisioning the egalitarian future, conveying that vision to our students, and using technology to achieve it. Without major efforts to eliminate the gender and race gap in the computer classroom from the earliest grades and in the workplace, we are in danger of perpetuating "the Star Trek syndrome."

On the Starship Enterprise we find the technologically advanced ("high-tech") society of the twenty-third century -- and the patriarchal, race and class-stratified social structure of the 1950s. Captain Kirk is the Great White Father figure, a nearly infallible leader. Persons of color are rare and the non-white male officers exemplify racial and cultural stereotypes that reflect American biases of the 1950s: for example, the Japanese officer, Lieutenant Sulu, is a

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computer/technology whiz and, in at least one episode, a freaked-out Samurai. Even the Russian officer is an American stereotype, talking constantly about how everything "vass inwented in Russia."

In fact, the only "minority" man in a position of leadership and authority is Mr. Spock -- a Vulcan -- he is in the category of an "exotic" who does not threaten white male dominance because he is from another planet; further, he is clearly seen as "inferior" because he is completely non-emotional or, as his friend the doctor keeps reminding him -- not "human."

Needless to say, Star Trek women are almost entirely in traditional roles -- as handmaidens, love interests, and window dressing. The only woman on the bridge, Lieutenant Uhura, is an African woman who serves as "communications officer" -- a high tech telephone operator. Other women who appear on Star Trek are twenty-third century Yuppies; they have Ph.D.s and are important scientists or doctors or diplomats, but the plot frequently revolves around their yearning for the dependency of an old-fashioned marriage and family. They resemble the stereotype of the bitter, dissatisfied career woman in Hollywood movies from the 1940s, whose lives are portrayed as empty and unfulfilled because they are not wives (often of Captain Kirk, a former lover) and/or mothers. There is a subliminal message here about what these high-powered women really need.

The Star Trek future is a bleak one for women and persons of color, as the basic patterns of discrimination, exclusion, and bias persist despite all the advanced technological gadgets and gimmicks. Although women and persons of color participate in the Star Trek future, they do not control it --

decisionmaking and leadership remain exclusively in the hands of white men and a Vulcan man. Clearly, the perpetuation of such stereotyped roles is unacceptable in a world in which the majority population is non-white and female and non-Vulcan.

But we will be on a direct course to the Star Trek future unless we attend to the equity issues in education today. Unequal access to the whole range of computer-related educational experiences today will produce the "technopeasants" of tomorrow -- an underclass of female and minority workers who are today's computer "have nots" because they are female and/or minority and/or poor.

Further, we would suggest that computer literacy -- however we ultimately define it -- is critical for all students. Even those who will not be programmers or systems analysts or inventors need to learn this basic skill, along with those other skills that we in the latter half of the twentieth century have come to define as "basic" (reading, writing, calculating) and those thinking and reasoning skills that are essential for informed decisionmaking.

Politicians, computer scientists, and engineers should not be the sole arbiters of political and ethical issues surrounding the uses of technology. But those who are ignorant of programming and of some knowledge of how this technology works are more likely to fear the computer's "power" and feel their own helplessness. Women cannot afford to give over the power to make informed decisions about how our lives and our society will adapt to new technologies. It is critical that women and persons of color -- who traditionally have been excluded from most positions and images of power -- have a share in this knowledge, have a sense that they can control the technology (i.e. can program the computer) and not be its slave.

Knowledge really can be power, as all autocrats have always known. Only the priests learned to read and write in the early middle ages in Europe and Black slaves in this country were forbidden by state laws to learn to read and write. Women were excluded from a wide range of educational experiences, including college, until the last century.

But what does "access" to this power, this knowledge, this technology, really mean? In the United States, urban, low-income, predominantly minority school districts have fewer computers than do suburban, wealthier districts, and boys still outnumber girls in high school programming classes by about two to one while girls predominate in business education and applications.

By the end of this decade, many of the simplest access problems may be solved by the simple increase in the number of computers in our schools. But we must realize that the appearance of equal access can mask subtle but serious inequities. For example -- students defined as "slow" (often because they are Black or Hispanic) may be limited to using only drill and practice software and may not be exposed to more sophisticated computer learning activities that have the potential to inspire greater achievement.

First and foremost today -- access means access to computers -- in school and at home -- and to sufficient instruction and user time. A key to equal access can be found in the studies showing that children who have computers at home have a substantial advantage over those (including most of the minority and female children) whose computer experience is one hour each week in school. There are 5 million computers in 27 million homes of 42 million school-aged children -- one for every five or six students. And most of these computers are in the most affluent homes. The importance of home computer use cannot be overestimated; one study found that having a home computer significantly improved low-income, minority children's educational skills and enthusiasm for learning. Twenty-two participants in a summer camp in 1984 used computers only in the camp's classrooms, while 14 were also given computers to use at home. The students with computers at home described a greater increase in "feelings of accomplishment and esteem" and in "awareness of themselves as students and as people with responsibility toward others." Their parents also were enthusiastic about the impact of the computers, because their children's learning increased, their attitude toward school improved, and they used their time at home more creatively.

Boys often have more computer experience by the time they get to school. A 1982 study in California found that 21 percent of the male sixth graders had home computers, but only 15 percent of the girls did. Uneven access to home computers leads to disparities in both interest in computers and achievement with computers, so parents hold an important key to the solution. Children who have computers at home and "use them as a normal, everyday tool of life" have a significant advantage over those who work on computers for an hour or less each week at school

But all available data indicate that children from low-income communities are the least likely of all children to have computers either at school or at home. And these children are most likely to be Black or Hispanic or to be living in households with a single, female parent. Carol Edwards (Project MICRO) shows how minority children are clearly excluded from access to computers; she points out that southern and western states with the highest concentrations of Blacks and Hispanics also have the lowest computer-to-student ratios in the country. In addition, the average annual income of families with home computers is $35,000 to $40,000, but the median income for Black families, according to the 1980 Census is less than $20,000; Black women who are sole heads of household earn less than $8,000.

We can hope that some of the recent data about young women's increasing interest in computers will also affect their course taking. But I am afraid that these data, when carefully assessed, also reflect the persistence of sex stereotyping and the impact of sex stereotyped assumptions about "women's work": After one computer course in high school, 52 percent of the young women expressed interest in taking more word processing and business applications while 59 percent of men were interested in more programming.

Why is this so? Clearly, men and women should be exposed to both applications and programming for a rounded exposure to the computer's potential. I suggest that it is stereotypic thinking on our part, conveyed to our young children, friends, and students that makes the difference.

The gender gap in the computer classroom is perpetuated by such stereotypic thinking -- often unconscious -- by all of us. To some extent, we are finding old wine in new bottles; we make the same statements about girls' apparent lack of aptitude and interest in computers that we made about their lack of interest and aptitude in math and science just a few years ago.

We believe that the depth of the problem of unconscious sexist and racist assumptions can be clarified by an analysis of some current research studies -- which we call "smokescreen research." This kind of research is increasing, and it is clothed in all the appropriate jargon to hide its similarity to the theories of nineteenth century physicians, who said that women were not physiologically suited for higher learning because it would make the blood go to their brains and thereby damage their reproductive capacity.

The findings that are of greatest concern to us today are those that attempt to define "innate" math abilities, especially when the popular press reports findings such as those from Johns Hopkins, that suggest that females are genetically less capable in mathematics than males. Indeed, the popular press has picked up on the latest findings of this research (reported in the Washington Post, April 8, 1985) to tell us that the "scientists" have proved that "children who reason very well in mathematics have a greater tendency than others to be left-handed, nearsighted or to suffer from allergies." Imagine the reaction of the average parent or teacher when she or he reads that researchers now believe that they "have gotten a biological component to the earlier data" that showed that boys are significantly superior to girls in mathematical skills.

Apparently the villain is testosterone; according to this research hypothesis, "if the developing fetus, male or female, was exposed to high levels of the male hormone testosterone, or exhibited a high fetal sensitivity to testosterone, the neurological development of the left hemisphere of the brain was slowed. . . As a result of the arrested development of the brain's left side, the right hemisphere compensated for the problem and grew larger."

Since the left hemisphere is associated with language skills and the right with mathematical and spatial abilities, it appears that this additional dose of testosterone improves boys' spatial and mathematical skills. To remind ourselves that the language we use defines our values, we could put this another way, and say that this research shows that testosterone poisoning leads to inferior language and communications abilities and unbalanced emphasis on mathematical skills in boys.

We suggest that it is time for responsible researchers to seriously evaluate this kind of research and reformulate both the research questions and conclusions. As educators and educational policymakers, we also must be wary of acccepting "research findings" without applying our own critical, skeptical analyses. Perhaps the key is to follow the lead of Evelyn Fox Keller, who asked: "How much of the nature of science is bound up with the idea of masculinity, and what would it mean for science if it were otherwise?" Indeed, if testosterone is such a problem, why is it glorified to such an extent in everything from university tenure committees to foreign policy to cigarette commercials to computer games?

It also would be useful to give more attention to the implications of other recent findings for our assessment of sex differences. For instance, researchers at the University of Texas and Columbia University found that the connective band of

tissue between the two hemispheres of the brain is larger in females than in males. This "finding suggests that there is greater communication between the right and left hemispheres in women than in men, [and that] women use both hemispheres cooperatively, whereas men rely more heavily on each side for a different purpose," according to one of the numerous newspaper accounts of this research. Doesn't this indicate an intellectual ability that transcends the linear, limited "male" way of thinking?

A caution: We are only discussing these studies to show that hidden assumptions of superiority can affect both our research designs and outcomes. We never recommend the presumption of genetic superiority for either sex or any race. Indeed, our purpose is to oppose any scientific-political efforts to define a particular sex or race as genetically superior. But we must insist that our colleagues be truly objective and rational in assessing all such research. Neither in our research nor public policy will we accept the de-valuing of women's skills and abilities just because our patriarchal science and social structure defines male as "better".

But even when women test "better" -- as in a recent test of programming skills -- the conclusions are not flattering. High school girls scored higher than boys on a computer programming test, but according to the report, the researchers believe that this may be so because "women tend to be better than men at following explicit instructions, which may make them better at understanding the nature and structure of computer programming. Boys are stronger in strategic thinking and better at reading flow charts and in solving mathematical problems."

These are extremely dangerous conclusions, relying as they do on stereotypic views of "feminine" versus "masculine" thinking and learning styles which have certainly not been proved to be inevitable. The real issue is not which sex excels at which task or style of thinking but rather -- which is valued. All too often we find that those talents defined as "male" are, by definition, more highly valued, just as work defined as "for men only" is more highly valued. This is sexism at work on the most subtle and sinister level.

We must be extremely careful of these assumptions and of what we say about "free choice" and "aptitude" and "lack of interest" in computers on the part of girls. Is it any wonder that girls learn that these preferences are "appropriate"? They see advertising for computers and for both educational and recreational software that tells them: "this is for boys." They learn early that those talents defined as "male" are, by definition, more highly valued by both school and society.

And girls receive different messages and treatment in many classrooms. A recent PEER Report, Learning Her Place: Sex Bias in the Elementary School Classroom, found that the "classroom climate continues to be heavily influenced by sexism and racism, often despite the good intentions of dedicated teachers." Our analysis of research on classroom interactions conducted during the past ten years found that "girls still are perceived more favorably, disciplined less harshly, and graded more generously than boys, but boys receive more attention, encouragement, and constructive criticism. Boys emerge from this environment ready to move ahead and surpass their female classmates. Girls bring to their further education and their career plans a habit of playing it safe and a collection of nagging doubts about their own abilities which often persist in contradiction to their exceptional grades." And because girls also are less likely to have computers available to them at home and in school and are less likely to be sent to computer camps by their parents, is it any wonder that they don't "choose" to take the courses of study

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deemed "non-traditional"? It is truly a circular argument. We decide that boys like computers and video games better than girls so we make them to appeal to boys and advertise them to boys and tell girls they won't be needing these skills (except for word processing) and then we are surprised when boys use them more than girls.

Further, we should ask why we, as parents and educators, would choose to value and try to appeal to boys' alleged preference for shoot-em-up game-playing rather than girls' alleged preference for quiet adventure? Why should "Jenny of the Prairie" -- a game produced by Rhiannon Computer Games for Girls which features adventures that require creative problem solving -- not be appealing to boys? We should consider the value of having both the male and female leaders of the future learn to think, not fight, their way out of difficulties and conflicts.

Again, we should ask ourselves when we ever have based our curriculum and pedagogy in elementary and secondary school on what boys and girls find "interesting"? I doubt that anyone over the age of 21 would agree that we should let a ten year old girl's preferences determine our educational goals for her. Many of us, at that age, would have suggested dropping school altogether. If girls -- for whatever reason -- appear to "prefer" word processing, does that mean we should simply accept their judgment? Rather, we should be working towards an androgynous education; but, where there has been exclusion and stereotyping, we absolutely must have compensation and remediation for girls. While we "mainstream" equity concerns throughout the curriculum, then, we still must retain the ability to make special efforts to bring girls and minority boys into that mainstream.

This has been a lengthy response to the question posed earlier: What is access? Put simply, access means access to equal treatment -- by parents who will send both sons and daughters to computer camp, by teachers who will treat students fairly and be sensitive to the need to overcome biased expectations, to non-racist, non-sexist, accessible software and advertising, without either subtle or overt discouraging messages to women and girls. In addition, our teaching methods and the substance of the curriculum and texts -- including software -- must be bias-free. If the content of the curriculum is alienating, access is not enough; Florence Howe calls this notion -- that simply putting boys and girls into the same classrooms will end inequities -- the "myth of coeducation."

And when we talk of access we also look to the future and ask: Where will our young students be working and what will they be contributing to society when they are adults? So access also means increased career options, especially for today's computer have-nots -- youngsters whose parents and school districts cannot afford computers and youngsters who are discouraged by race and sex stereotypes and discrimination.

In computer-related jobs today, women still predominate in those with less control, status and pay. Women are operators -- doing data entry, word processing, and phone operator jobs. Men are more likely to be programmers and systems analysts, designers, managers.

As we move toward the year 2000, let us vow to concentrate our efforts on creating a truly egalitarian twenty-first century. We must begin with our own backyards -- our schools and corporations and homes -- as well as with efforts to change federal and state policies. Young girls today need our help to take them -- to paraphrase Star Trek -- "where no woman has gone before!"

A CAUSAL MODEL AND AN INTERVENTION MODEL:

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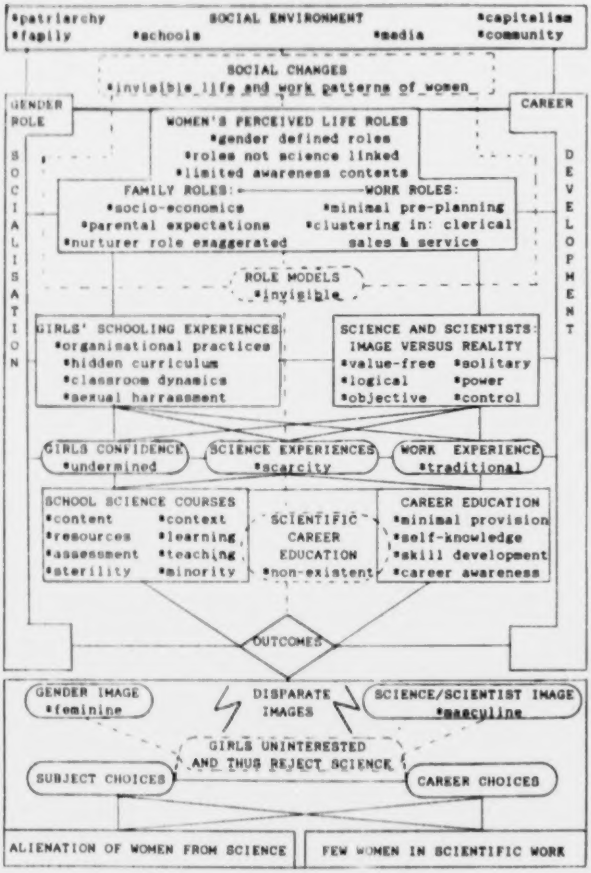
A CAUSAL MODEL:

FIGURE 1. A CAUSAL MODEL


SOCIAL ENVIRONMENT
*patriarchy
*capitalism
*family
*schools
*media
*community
SOCIAL CHANGES
*invisible life and work patterns of women
GENDER ROLE
CAREER
SOCIALISATION
DEVELOPMENT
WOMEN'S PERCEIVED LIFE ROLES
*gender defined roles
*roles not science linked
*limited awareness contexts
FAMILY ROLES:
WORK ROLES:
*socio-economics
*minimal pre-planning
*parental expectations
*clustering in: clerical
*nurturer role exaggerated
sales & service
ROLE MODELS
*invisible
GIRLS' SCHOOLING EXPERIENCES
*organisational practices
*hidden curriculum
*classroom dynamics
*sexual harrassment
SCIENCE AND SCIENTISTS: IMAGE VERSUS REALITY
*value-free
*solitary
*logical
*power
*objective
*control
GIRLS CONFIDENCE
*undermined
SCIENCE EXPERIENCES
*scarcity
WORK EXPERIENCE
*traditional
SCHOOL SCIENCE COURSES
*content
*context
*resources
*learning
*assessment
*teaching
*sterility
*minority
SCIENTIFIC CAREER EDUCATION
*non-existent
CAREER EDUCATION
*minimal provision
*self-knowledge
*skill development
*career awareness
OUTCOMES
GENDER IMAGE
*feminine
DISPARATE IMAGES
SCIENCE/SCIENTIST IMAGE
*masculine
GIRLS UNINTERESTED AND THUS REJECT SCIENCE
SUBJECT CHOICES
CAREER CHOICES
ALIENATION OF WOMEN FROM SCIENCE
FEW WOMEN IN SCIENTIFIC WORK

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It is suggested that a girls and science causal model might be a block recursive model with a lens-like broad causal path formed from a web-like pattern of interconnected factor blocks. The model acts to produce the well-documented differential outcomes of science education for girls. (See the image of the suggested causal model in Figure 1.)

The model incorporates the continual permeating influences of gender role socialisation and of career development, which both interact with the main factor blocks in a repetitive manner. It also seeks to show the links between the confidence level of girls; their early science experiences; and any work experience that is undertaken, either as part-time student employment or within school.

Dotted lines are used in the schematic model to represent invisible influences such as the hidden existence of women's changing social role patterns; the apparent obscurity of successful women working in science; and the non-existence of scientific career education. Each of these invisible factor blocks exerts an insidious power over the final outcomes, yet their evanescence ensures that they are frequently unrecognised by teachers, parents or students.

The outcome block of the causal model illustrates how girls' rejection of science, both as a vocational area and as a perspective from which to feel empowered in viewing the world, is moderated by the slow erasure of girls' initial curiosity and interest in the natural world. This developed lack of interest in science thus acts as a filter through which the outcomes are modified.

AN INTERVENTION MODEL:

A proposed intervention model, as shown schematically in Figure 2 includes components for: the aims of the intervention; the levels and agents of intervention; strategy types; and ways in which the effectiveness of the evaluations can be judged. This short paper will concentrate on one section of the this model: school level strategies.

Because the postulated reasons for girls' rejection of science are multi-dimensional with interlocking connections, then the strategies which have been suggested are also diverse with an integrating lattice of influence. It is suggested that if both girls' attitides, and their actions in choosing and succeeding in science are to be affected, then intervention must occur at several of the points indicated by the model.

WHOLE SCHOOL STRATEGIES: a) AWARENESS AND ATTITUDES:

Activities can be organised to meet the needs of parents, students or teachers. An initial activity is to establish communication links within and between these groups, through such avenues as newsletters, circulation lists, and discussion sessions which may lead to the creation of support networks. Local data collection of

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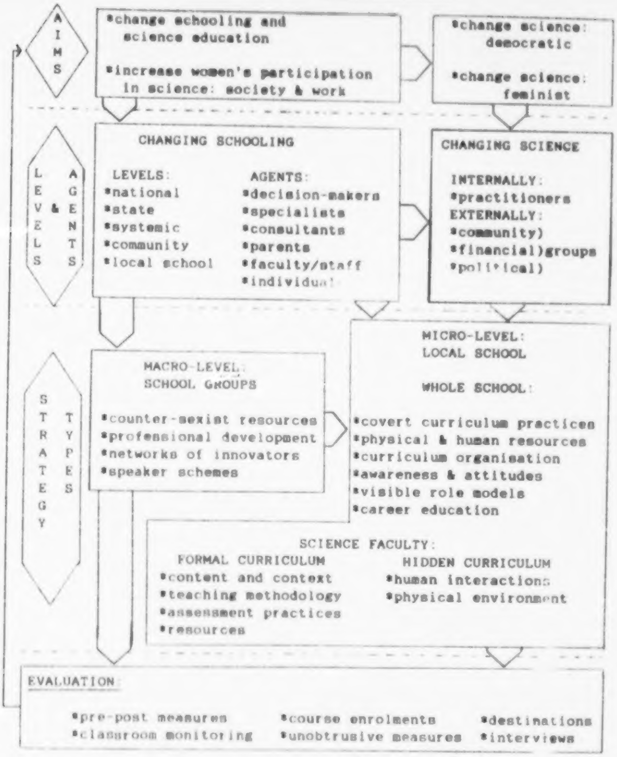
FIGURE 2: AN INTERVENTION MODEL


AIMS
*change schooling and science education
*increase women's participation in science: society & work
*change science: democratic
*change science: feminist
LEVELS & AGENTS
CHANGING SCHOOLING
LEVELS:
*national
*state
*systemic
*community
*local school
AGENTS:
*decision-makers
*specialists
*consultants
*parents
*faculty/staff
*individual
CHANGING SCIENCE
INTERNALLY:
*practitioners
EXTERNALLY:
*community)
*financial)groups
*political)
STRATEGY TYPES
MACRO-LEVEL:
SCHOOL GROUPS
*counter-sexist resources
*professional development
*networks of innovators
*speaker schemes
MICRO-LEVEL:
LOCAL SCHOOL
WHOLE SCHOOL:
*covert curriculum practices
*physical & human resources
*curriculum organisation
*awareness & attitudes
*visible role models
*career education
SCIENCE FACULTY:
FORMAL CURRICULUM
*content and context
*teaching methodology
*assessment practices
*resources
HIDDEN CURRICULUM
*human interactions
*physical environment
EVALUATION:
*pre-post measures
*classroom monitoring
*course enrolments
*unobtrusive measures
*destinations
*interviews

subject enrolment patterns and school-leaver destinations can provide a base which is then "owned" by the school community who can thus be stimulated to plan and implement further action as a result. The introduction of "horizon-expanding" days, and special courses such as assertiveness training, human relations and women's studies, also belong to this cluster of factors.

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b) HUMAN AND PHYSICAL RESOURCES

Human resource strategies include: providing a careers teacher, or counsellor; promoting women to leadership roles within the school; and assigning staff to classes in non-traditional ways, such as a woman for physics.

Physical resource strategies may require money and a re-allocation of spaces, and include: establishing a careers reference centre; establishing a room where girls are free to relax without retreating to the locker rooms; re-juvenating classrooms and laboratories so they become comfortable environments; and purchasing counter-sexist resources such as videos, posters and books.

c) CAREER EDUCATION

A career education program could be integrated across the entire curriculum, including science, so that it incorporates aspects of the three components of career education: self-knowledge, skill development and career awareness. It could focus around a work experience scheme, which involved the placement and support of girls in non-traditional areas, including scientific work.

d) CURRICULUM: ORGANISATION AND COVERT PRACTICES

Organisational changes could include establishing single-sex classes in science in the middle secondary years; minimising pre-requisites that act as barriers to the continuation of learning; and/or the creation of alternative pathways, perhaps via bridging courses. Reducing curriculum options which permit girls to elect out of science, and ensuring that whenever choice does occur that the timetable is not based on stereotyped assumptions about choice patterns, are two further strategies from this block. Changing the internalised practices of the school, for example, through the monitoring and analysis of classroom dynamics patterns and sexual harrassment are also included.

e) VISIBLE ROLE MODELS:

The role models can be drawn from the wider society and its workforce, from the school environment generally, or from specialist areas like science. The positive role models may be eminent persons, historical figures, local community members, parents, teachers, ex-students, or older students engaged in programs like cross-age tutoring schemes.

Students may interact with role models in person, through visits to workplaces (either excursions or work experience), through horizoh-expanding conferences, and through inviting visitors to the class, arranged locally, or through speaker schemes. The role models could also be simple visible images , brought to the attention of students though videos, posters, worksheets and books.

In some cases, especially if the role models are older students, ex-students, parents, teachers or local community members, the role model scheme could develop into a "mentor" scheme where longer term relationships can form, and an advisory and supportive function can be incorporated.

SCIENCE FACULTY STRATEGIES: a) FORMAL CURRICULUM

1. Content and Context:

School based curriculum development can change the content and context of the science curriculum so that it is entered from a values perspective, and centres around local and global issues with emphasis on the social implications and the everyday applicability of the science taught. The organising schema becomes a problem solving focus or historical perspectives incorporating both a people-oriented view, and notions of the changing nature of our scientific understandings. Aesthetic and creative aspects of science could be illustrated through student negotiated research projects, which are reported through a variety of media.

2. Methodologies

The methodologies could focus around a "hands-on", practical orientation, with built-in compensatory experiences where appropriate. An emphasis on discovery learning though student-generated problems, could assist in the development of process skills, and whenever concrete materials were unsuitable, creative techniques such as simulation games and role plays could be utilised.

3. Assessment

Assessment practices could counter teacher bias through consensus moderation techniques, through the use of students acting as self- and peer-assessors; and through the use of a variety of information collection avenues, such as project reports, created posters, and photographic essays. Written test items could be set in the social context, portray active women and not be solely multiple choice.

4. Resources:

Gender inclusiveness could be a criteria for the selection of all resources. The style, language, presented images, and experienced-based applications could be analysed to determine whether contributions and perspectives of women are equally valued.

b) COVERT CURRICULUM

1. Human Interactions:

These include: professional development and support of teachers, especially to encourage changed practices to a more "facilitative" role within co-operative learning settings; analysis of classroom dynamics and the possible enforcement of single-sex practical groups, and monitoring class numbers to ensure that "critical mass" figures exist.

2. Physical Environment

Students can be provided with funds and materials to re-decorate parts of the laboratories, so that a sense of "ownership" prevails. Renaming rooms,from "G2" to "The McClintock Room"; using colour, carpeted areas, and live plants and animals to create a personalised atmosphere; and using wall space for people posters, and notice-boards for "everyday science", "science news" and "science careers" displays, are examples from this strategy block.

The list of strategies is not exhaustive, but merely illustrative: there is much work to be done, before we know which interventions are effective and sufficient.

NOTES: The ideas for the strategy types are occasionally my own, tried in a school, but more frequently those of others. I have been stimulated by many other workers in this field and cannot accurately give acknowledgement to the originators of each individual strategy. I thank you all.

SCIENCE FOR ALL: A CASE STUDY

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American Association for the Advancement of Science

The United States has a highly decentralized education "system" with 15,352 individual school districts ranging in size from New York City with 984 schools serving 918,358 students to Saltese Elementary School District in St. Regis, Montana, and Cat Creek School District in Jordan, Montana, with two students each in grades K-8. (Department of Education). Over 600 districts have total enrollments of under 50 students and over 2,200 districts have total enrollments of under 100 students (Electronic Directory of Education, 1986). Any attempts to achieve equity in the delivery of science instruction must deal with these realities.

Taking the problem of girls' and young women's lack of access to appropriate, equitable science and mathematics instruction down to the individual classroom or school is, in the long run, the only way to institutionalize practices that have been shown to be effective with these students in out-of-school programs (Office of Opportunities in Science, 1984 and Malcom, 1985). Such strategies as documenting the differential enrollment of female and male students in upper level science and mathematics classes in one's own school have been employed effectively by the EQUALS program, a teacher training model of the Lawrence Hall of Science, as a first "awareness" step toward changing teacher practices.

More recently the Linkages Project of the AAAS Office of Opportunities in Science has utilized a similar strategy in training community representatives from seven local groups across the United States as part of an effort undertaken with the League of Women Voters Education Fund (Early, unpublished manuscript). We expected that subsequent publicity given of locally drawn data, buttressed by national sample data from the Center for Statistics and selected research reports, would enable those communities to "own" the problem of inequitable participation in science and mathematics courses in their local schools. We also wanted to encourage the community groups to advocate for and support efforts to produce, equity in science and mathematics education.

In Fall 1983, a planned evaluation of the K-12 science education curriculum of the Howard County, Maryland Public Schools gave this author an opportunity to look at equity in a total school system setting. System staff utilized over 60 community volunteers with academic training and backgrounds in science, engineering and related fields to assist them in conducting an assessment of the science program in the schools. The idea was that persons trained in and/or using science on a daily basis could provide a unique perspective as to whether the science education provided in the schools was appropriate to producing potential scientists, engineers or biomedical professionals as well as science literate citizens. It was also felt that such volunteers from the community could tell whether science in school was an accurate portrait of science in practice. The original study design, which was devised by the evaluation staff, was comprehensive and included examination of philosophy, goals and objectives; laboratory facilities, equipment and materials; print and nonprint teaching materials; the quality of the teaching process; instructional support systems; and student outcomes. Over 300 visits were made to science classrooms at all organizational levels. Parents, students, administrative and instructional staff were interviewed, and questionnaires were completed by these same groups.

Two science consultants worked with staff and citizen task force members during this process, one on the elementary level and one on the secondary level. Although the original design was "comprehensive" in that it included examination of those elements generally agreed upon as being the major inputs into science learning and achievement, it did not include equity as a specific concern. It was possible, however, during the evaluation period to "negotiate" the inclusion of equity concerns into the work of the Middle School Biological Sciences Task Force. The teaching process and student outcomes were examined in depth in an attempt to understand how the system that we were assessing was perceived by and working for female and minority students.

Methods

Gender breakouts were obtained for affective test scales administered to 1,823 eighth grade students in spring 1984 using released attitude items from the National Assessment of Education Progress (Science). High school science coursetaking data broken out by gender and race/ethnic group were also examined. Classroom observation and other available data amassed during the review were used to assist in interpreting student outcome data.

Findings

By the end of the middle grades (ages 13-14) the science classroom is perceived differently by male and female students. Fewer males than females reported that science classes were boring ($p < .0001$); females were less enthusiastic about going to science class ($p = .0015$) and female students were more likely to say they were afraid to ask questions in class ($p = .0110$). Female students were less likely to say that the things studied in science classes were things they had already learned outside of school ($p = .0034$); less likely to report that science classes make them feel curious ($p = .0001$); confident ($p < .0001$); or successful ($p < .0001$). Female students engaged in fewer science activities outside of class (8 items showing significance levels ranging from $p < .0001$ to $p = .0325$). Although girls were as likely as boys to believe that there were science-related jobs they could learn to do, they were less likely to say that they wanted information about jobs in science or engineering ($p < .0001$). Girls were not as strongly connected to career goals in science although they believed science was something they could do. Female students took less science in high schools than male students, especially upper level and honors classes in the physical sciences. Overall the middle school that showed the strongest "liking" and interest by students was the major feeder school for the high school which had the highest nonrequired science enrollment, with over 83% of students taking at least one science course.

Discussion

Data from High School and Beyond, a 1980's longitudinal study of high school seniors, reveal that female students were as likely as male students to take a first course in chemistry and slightly more likely to take courses in biology. At the same time female students were much less likely to take courses in physics and other advanced courses in the physical sciences (Vetter and Babco, 1986). For example, 14.5% of male and 8.4% of female high school seniors in 1980 and 1982 reported taking the first level course in physics. Interestingly, data from this same source reveal that coursetaking patterns in mathematics of male and female students are converging.

The study of Howard County Schools indicated similar patterns of high school science coursetaking to those seen with nationally derived data -- a falloff in science coursetaking by female students for the upper level physical sciences and honors courses, except for biology. Female students in Howard County were a majority of enrollees for honors earth science (grade 9) and honors biology (grade 10), but they did not maintain this advantage during grades 11 and 12.

A similar and subsequent evaluation of the mathematics program in the County Schools did not contain an equity focus, but mathematics enrollment data reveal that female students were as likely to take mathematics courses as were male students. An article in the local newspaper three years ago pointed out the equitable distribution of male and female students in County School mathematics courses and quoted a supervisor as having had EQUALS training provided to mathematics teachers in the County some years earlier. While it is not possible to attribute the equitable mathematics course distributions of female and male students to EQUALS alone (or even EQUALS plus concern for equity from the supervisory levels in mathematics), it is clear that the social forces operating on course enrollments in science are independent of those operating on course enrollments in mathematics in the County.

The differences in affective data seen at grade 8 for male and female students were highly suggestive. Although female students are performing as well or better than their male peers, they have different attitudes about science -- their place in it, science relative to their out-of-school experiences, how school science makes them feel and their experiences in the classroom.

Work by Kahle, Eccles and other researchers tell us that we should not be surprised at the findings from this single school system case study. The unique design process involving community "researchers," many of whom are parents, encourages ownership of the problems and support of the program, and ensures attention to the subject area within the many competing demands which school systems are forced to address. Community involvement in assessment also requires considerable courage since nothing is hidden from view. Such open cooperation between schools and communities can be used to effect positive change and is offered as a model for local assessment.

Implications

The lessons to be learned are important ones, especially for the parent of two girls, who attend school in this system, and who also happens to be in "the equity business."

(1) Inequities appear throughout the system of science education delivery in school and out-of-school settings; so efforts to "fix the process" must be systemwide.

(2) Efforts to "fix the system" must begin early, before inequities become obvious. Attitudes change prior to the point where coursetaking differences are apparent between males and females, and do not necessarily track with performance measures for female students.

(3) Equity concerns must receive broader attention from educators and policymakers; homogenizing the issue of declining participation in science education overall will not bring increased enrollments, when over two-thirds of the enrolled

students are from groups which are underrepresented in science (women, minorities and disabled persons).

(4) One key to equity in science is the teacher. Knowledge of equity issues must become a tested element for any movement to certify teachers. Only when this is done will colleges and universities include equity concerns prominently in its training of teachers in pedagogy, classroom management and educational foundations.

(5) More and better tools, materials and instruments are needed for inservice and preservice training of teachers in equitable classroom practices in science.

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THE ACHIEVMENT AND RETENTION OF FEMALES IN SCIENCE IN WA

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The paper begins by summarising previous research on science enrolments in Western Australian primary schools (Years K - 7 for students aged 5 - 12 years) and in the first three years of secondary schooling (Years 8 - 10, for students aged 13 - 15 years). It then goes on to present more detailed information on students′ participation in science during the post-compulsory years of secondary education (Years 11 and 12 for students aged 16 and 17 years). In the discussion of this information some strategies are proposed with the aim of reducing the sex-stereotyping of science which is currently so strongly in evidence at the upper secondary school level.

Science in Primary School

In Western Australian primary schools, science, in the past does not appear to have been regarded as an area of high priority. A number of studies have indicated that between three and eight percent of total classroom time is allocated to science, and that science clearly suffers by comparison to areas such as mathematics, which receives around 15 per cent of classroom time, (eg Rowe, 1983. Rennie, Parker & Hutchinson, 1985). While these studies have not addressed the issue of sex differences in achievement explicitly, one of them (Rennie et al) reports that teachers expect girls to show less interest, experience more difficulties, perform less well and have lower self-confidence in physical science than in biological science. It was also found that teachers expect, in the physical science areas, girls′ interest and

and confidence to be less than those of boys, and their experience of difficulty greater than that of boys. Importantly, these teacher expectations were not borne out by reality in situations where teachers had adequate skills for teaching a physical science topic in a non-sexist manner.In summary then, the tradition in Western Australian primary schools is that very little science is taught, and that where it is offered, there is a danger that, with teacher expectations as they are, a self fulfilling effect could well be operating in terms of different future outcomes for male and female students in physical and biological sciences.

Science in the Lower Secondary School

On completion of their primary schooling, Western Australian students move from a situation in which there is virtually no science instruction to one in which Science is a compulsory subject. For approximately four hours per week during each of the first three years of secondary school, all students study a standard multidisciplinary course which includes topics from the traditional scientific disciplines of Physics, Chemistry, Biology, Earth Sciences and Astronomy.

There is thus an unusual degree of uniformity throughout the State in relation to both the amount of time students spend on science and the actual science courses studied. As described in detail elsewhere (Parker and Offer, 1987), in this situation, where girls and boys share a common school science experience in terms of both the number and the nature of science courses taken, sex-differences in science achievement vanish. Since 1980, the mean Science achievement of females has actually been slightly higher than that of males at age 15 years (Year 10). It might be expected, then, that females would continue in considerable numbers to study science subjects at the upper secondary school level. Such is not the case, however, as will be demonstrated in the following section.

Science at the Upper Secondary School Level

The structure of the curriculum at the upper secondary level in Western Australia differs considerably from that at the lower secondary level. At the end of Year 10, students are able to exercise considerable choice in regard to their studies at Year 11 and 12 levels. Typically each student chooses six subjects from the fairly wide range available in her/his school. Between 70 and 80 per cent of students (comprised of females and males in the ratio of approximately 0.8:1) choose at least one science subject. Almost all schools offer Biology, Chemistry, Human Biology and Physics. Many also offer Physical Science, an integrated physics and chemistry course which addresses explicitly the science/society interface. Relatively few offer Geology and a topic-based general course called Senior Science. The latter is regarded generally as a science course for lower ability students, while all of the other six science subjects are of a more academic nature and are accepted as suitable preparation for tertiary studies in science.

Tables I and II provide information relevant to the enrolment of females and males in the five major upper secondary school science subjects described above.

The figures in Table I are based on approximately ten per cent random sample of students in each of the 1984 and 1985 Year 11 cohorts in Western Australian secondary schools. They demonstrate clearly the manner in which science choices at the upper secondary school level are sex-stereotyped. In general, boys predominate in the physical sciences and girls in the biological sciences. The exception is the subject called Physical Science, which, as indicated earlier, gives students the opportunity to continue with both physics and chemistry within a framework emphasising environmental and societal applications. It could well be that this structure and approach makes the subject more makes

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the subject more appealing to girls than traditional physics and chemistry courses.

The figures in Table II show the science enrolments of students from the Year 11 1985 sample cohort who continued on at school into Year 12 1986. In all five subjects the retention rate for girls is greater than the overall rate for girls from Year 11 into Year 12. This is also true for boys in all cases except Physical Science, which appears to be taken by a number of boys who leave school at the end of Year 11.Thus, although the retention of girls is low relative to that for boys, generally speaking if a student selects a science subject in Year 11, she/he tends to continue with it in Year 12.

Considered together, Tables I and II demonstrate clearly that the "choice point" - the point at which the secondary school curriculum in Western Australia allows students freedom to choose whether they will continue to study science, and if so, which science subjects - is indeed a critical event in the science education of both girls and boys. In addition, the comparison between the 1984 and 1985 Year 11 enrolments shown in Table I sheds further light on this issue. The year 1985 witnessed the introduction of a major upper school curriculum change in the Western Australian system, a change which gave students a great deal more choice as regards their selection of upper school subjects than they had enjoyed previously. It appears from Table I that the more freedom students are allowed at the choice point the less likely they are to choose a science subject, and that this is especially true of girls.

Implications for Educational Practice

The situation described above would appear to be educationally undesirable from a number of points of view. Most educators would hope and indeed expect that students choose school subjects for logical, relevant reasons, associated in particular with their previous achievement. When an irrelevant factor such as gender appears to be so closely associated with particular patterns of subject choice it is cause for concern.

Overall the very different images of "science for males" and "science for females" perpetuated in schools ensures that each sex is exposed only to half the scientific world at school level, and in the longer term reduces the likelihood of the physical sciences ever becoming a "human" rather than a "male" area of study. In relation to the national interest, this situation also leads to a tremendous wastage of scientific talent, particularly the talent of girls in the physical sciences.

The problem for educators to address concerns strategies for changing the situation described above. It is not a new problem. A number of strategies have been tried at both primary and secondary school levels. The information presented in this paper, however, suggests two possible lines of action which may not previously have been given serious consideration. One of these concerns the existence and timing of the "choice point" and the other concerns the nature of the upper school science curriculum.

The Existence and Timing of the "Choice Point"

Most Australians are socialised to value choice as a democratic right. In an educational sense, moves to increase the range of options and flexibility which students have in their choice of subjects at school are generally viewed as desirable. This paper would tend to suggest, however, that increasing students' choice and widening their options may be detrimental to their education in science in a number of ways. It is frequently stated, or at least implied, that a major purpose of schools is to open doors to students, and to give them knowledge which they would be unlikely to obtain otherwise. This paper has shown that allowing students more choice, at age 15, of what they will study in upper secondary school, tends, if anything to close doors to them. It suggests that to define science as a compulsory area of study right through secondary schooling might well be in the ultimate interests of both girls and boys.

Nature of the Upper School Science Curriculum

This paper also suggests that simply to define science as a compulsory area of study may not be sufficient. In Western Australia at present, the majority of students already study a science subject right through their schooling. The problem lies in the subject-centred structure of the upper school science curriculum - a structure which encourages a strongly sex-stereotyped pattern of subject choice. An obvious solution lies in the provision of a multidisciplinary, academically demanding science subject, designed to ensure that all areas of science remain the province of both males and females, at least throughout their schooling.

Concluding Comments

This paper has provided further evidence of a problem which has been acknowledged for some time, namely, the sex-stereotyping, at school level, of the physical sciences as a male domain and the biological sciences as a female domain. It has been shown that such stereotyping is inconsistent with the demonstrated achievement of females and males in science, and it has been argued that the situation is detrimental to individuals, to science and to the national interest.

The paper points out firstly, that girls and boys achieve equally well in science when studying a common curriculum for the same amount of time, and secondly, that increasing the amount of subject choice available to students appears to decrease the probability of them studying science. On the basis of this information it proposes a solution to the problem of sex-stereotyping, a solution which is at once both radical and reactionary. Basically, the solution is to require students to study a multidisciplinary science course right through their secondary schooling.

The fact that the proposed solution strikes at the very heart of conventional wisdom regarding the desirability of freedom of choice may make it unappealing to many. It may well be, however, that this solution is viable, economical, and in the best interests of all concerned.

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TABLE I

Frequency of Choice of Science Subjects by Females and Males Year 11, 1984 and 1985*, Western Australia.

	1984			1985		
	Ratio F:M	% of F	% of M	Ratio F:M	% of F	% of M
BIOLOGY	1.28:1	44.3	32.7	1.07:1	24.8	24.2
CHEMISTRY	0.47:1	21.6	43.6	0.56:1	17.0	31.6
HUMAN BIOLOGY	2.12:1	49.0	21.8	2.73:1	54.0	20.7
PHYSICAL SCIENCE	0.61:1	8.0	12.4	0.67:1	7.3	11.4
PHYSICS	0.35:1	17.2	45.6	0.39:1	12.5	33.6

*Figures based on approximately 10 per cent random sample of Year 11 cohort.

Females (F) = 774 students (1984) 1026 students (1985)
Males (M) = 823 students (1984) 979 students (1985)

TABLE II

Frequency of Choice of Science Subjects in Year 12, 1986, Amongst Females and Males retained from the 10 per cent random sample studied in Year 11, 1985*

	Year 12, 1986				
	Ratio F:M	% of F	Retention From Yr.11	% of M	Retention from Yr.11
BIOLOGY 12	1.21:1	27.4	84.6%	24.2	75.1%
CHEMISTRY 12	0.54:1	18.9	85.1%	37.0	88.0%
HUMAN BIOLOGY 12	2.82:1	55.0	78.0%	20.8	75.4%
PHYSICAL SCIENCE 12	0.76:1	7.5	78.7%	10.6	69.6%
PHYSICS 12	0.35:1	12.5	76.6%	38.5	86.0%

*In Year 12, 1986. Females (F) = 785 students (76.5% retention from Year 11, 1985)

Males (M) = 736 students (75.2% retention from Year 11, 1985)

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Concept development in the natural sciences:stimulating for girls

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Concept development in the natural sciences: stimulating for girls

Girls perform worse than boys in science. There are many causes for this fact, such as tradition, masculine character, the fear for technical equipment and the influence of teachers and fellow-pupils. Another cause is the way in which the subject is taught: abstract, detached and far from reality. There are two aspects that are relevant with respect to this: the use of contexts (which means placing the contents of a subject in concrete situations) and the way concepts are introduced. I have in particular concentrated on this second aspect.

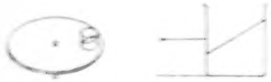
Hypothesis

Traditional education is based on the conveyance of knowledge at classical level. Concepts are defined, explained and then applied. The teacher instructs or has a discussion with the class. All pupils are subjected to the same speed of instruction. Concept development may be described as teaching responses to certain stimuli (the SR's). Next these SR's are linked to SR-chains of great complexity in the expectation that when a sufficient number of SR-chains have been formed pupils will be able to think independently. These chains are viewed as having logical properties. However, there are two problems with this: first of all it is very well possible that pupils may not perceive all the SR-steps, and secondly pupils may not think that this logical pattern is logical. This may be shown by the following examples: when it is said that force is the cause of acceleration this isn't the case for velocity, because the sum of all forces on a body that moves with steady motion is zero. The statement that materials consist of molecules and that molecules consist of atoms may also be quite difficult for them to understand. These concepts are not part of the experiences of pupils, which is shown by the existence of the so called misconceptions. A cyclist who moves with a constant speed exerts a greater force than the opposing forces, because he or she has to overcome the opposing forces.

Concept developing education (CD) is education that lets the pupils develop concepts by means of practical situations and that also elaborates on what pupils themselves have given as answers to posed questions. This also gives due to the ideas which children have formed through their upbringing. We prefer to let pupils work out tasks in groups and there's also a certain degree of freedom of working pace (differentation of pace). Basing myself on these two mentioned models of education I would like to advance the following thesis: Concept developing education (CD) stimulates the participation of girls in learning the natural sciences, while the teaching by means of often not understood SR-chains obstructs the participation of girls in science education to a great extent.

Examples of concept development

We will take the example of centripetal force. Pupils say when they take a bend, for instance in a car, when skiing or bobbing or in a river, that there is an outward force because you can feel it. They don't think that there is an inward force. Well, you can carry out the following experiment: fill a flat aquarium half full with water, pull the aquarium and the water level will have a certain shape. There is a relation between force and form with respect to the water level. Next place the flat aquarium on a rotating plateau and turn it. The direction of the force then can be judged by the form of the water level.

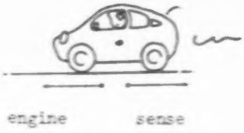


Centripetal!

However, this way of explaining things does not work with all pupils. It is often much better to use their own language. With the example of the river, the pupils say that

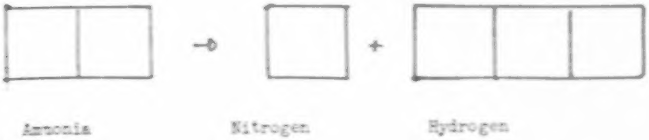
- .The water wants to go straight on
- .So you have to force the river to make a bend
- .In order to do this you need a force

For all examples pupils may spontaneously say that there is an apparent inward force. But they feel an outward force. Why's that? To try to explain this we can use an example of a car that accelerates fast: you know that there is a forward, but you sense a backward force.

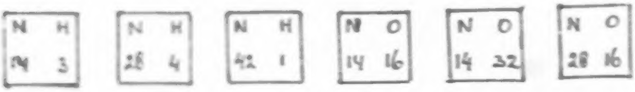


After this analogous example the pupils said spontaneously: 'So this means that the outward force is a reaction force'.
This example shows how important it is to give the experiences of pupils a physical significance. It prevents them from feeling that there are two worlds: the trivial world of daily experience and the abstract world of physics.

Another example is that of chemical formulas such as NH_3 and C_2H_5OH, of which the meaning and origin isn't always very clear to pupils. Working with these formulas is a kind of chemical algebra to them that has no relation whatsoever with reality.
We introduced the formulas as follows:
. By analyzing gaseous substances and gauging the volumes the pupils learned about the Law of Gay-Lussac.
. Chemical reactions were depicted by means of block diagrams.



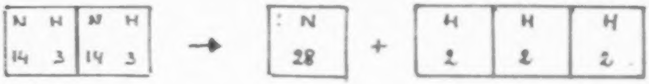
For practical reasons we chose 22,4 litre as the size of the block diagrams. In the blocks we wrote the masses of the various elements. Then we compared the blocks with the different elements with each other.



This comparison shows the following: each substance consists of one or more elements.

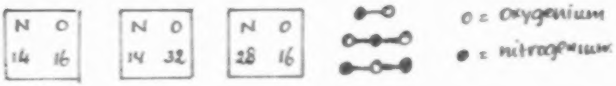
The following statement applies to all present elements: there is a minimum quantity of mass for N: either 14 or a multiple of this: so 28, or 42 etc., which is equivalent to 1, 2, 3.....times that minimum mass.
Using this construction pupils deduced formulas from these combinations without much effort

By writing these quantities in the block schemes of reactions it was quite easy for them to find the reaction equations:



$$2\,NH_3 \rightarrow N_2 + 3\,H_2$$

By comparing simple combinations of balls from the molecule box of building blocks with the gas blocks in question the pupils succeeded in attributing the correct molecule composition to the gas blocks.



In this way pupils learn that by perception, arranging facts and reflection science is practised which is also relevant to them.

We can observe the following aspects of concept development:
. An experiment that breaks set frameworks.
. Formation of language.
. Analogy.
. Creating an abstract object.

Results

-CD meant better results for boys as well as girls. However, with physics the results of girls were less good than those of boys. With chemistry they were the same.

-With chemistry we achieved the result of 95% sufficient.

-The group of girls who had decided to take up physics doubled.

-In the first year of physics the results of girls were less good than those of boys, however in the second year they made up again for this. The differentation of pace is more obvious in the case of boys.

-Girls often said that they liked the subject.

Discussion

The bad results with SR and the improvement with CD can be explained as follows:

- Traditional education is based on pupils who have a quick mind, and with science in general these are boys. Girls can't cope, they fall into the category of 'insufficient' and quit.
- Girls quit when uncomprehended abstract subjects are discussed. Girls have a legitimized escape route: they don't have to achieve so much, it is said. Because everyone expects boys to be successful and they know that when they choose and work hard at the exact subjects they will have a greater chance of having a successful career.

Here we see that how socialisation and traditional education reinforce and influence each other.

The fact that girls still have less good results than boys may be explained by the following:

- Socialisation.
- The still existing masculine image of physics
- The physics course is still not perfect (in the sense that the chemistry lessons were better, because they profited from the previously constructed physics course). With physics there were also SR-chains present in the lessons (which in general are learned by boys and skipped by girls).

Although we still have a long way to go, these results are encouraging, but we should not expect everything to go smooth at once when trying to improve the educational system.

As a final observation it is interesting to note that boys also achieved better with CD than with SR. So we see that what doesn't always work for girls, the system of SR, also doesn't always work for boys.

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CAREER PATTERNS OF Ph.D WOMEN AT THE WEIZMANN INSTITUTE

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It is generally accepted that a difference exists between male and female scientists in several aspects (Graham 1970, Kashket 1974, Bayer & Astin 1975). In the United States women are under-represented among recipients of the Ph.D degree (only 18% in 1973) and especially among recipients of this degree in science - only 10% of this degree in 1974 (Vetter 1976). By 1981 the percentage of women who received the Ph.D degree in science had increased to only 17% (Ware, Steckler & Leserman, 1985). Ph.D women are also under-represented on the faculty of prestigious universities, and their percentage is higher on the faculty of colleges. A comparison of the status of men and women in the same university shows that men usually have higher academic rank and most chairmen of departments, deans, and university presidents are men. Most women hold junior positions, and many have non academic appointments (Vetter 1975,1976). The percentage of women with tenure at universities and colleges in the US was shown to be 27% as compared to 56.9% for men (Vetter 1975). Women at universities have more teaching responsibilities (Zuckerman & Cole 1975), they receive less help in carrying out research, and have fewer assistants and less financial support. As a result of this, women are often less productive as judged by the

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number of their publications (Cole & Cole 1973, Zuckerman & Cole 1975). This is a vicious cycle because scientists who publish few papers are not appreciated by the scientific community and this adds to their difficulty in obtaining financial support, which is essential for scientific research. This hypothesis of accumulating disadvantages can partially explain the phenomenon of stratification in science (Merton 1968) and the inequality in productivity and in recognition. These facts do not conform to the principle of universalism in science (Allison, Long & Krause, 1982). The most pronounced difference between men and women holding a Ph.D degree in the US is their salary. At each level of the academic career, in colleges and universities, the income of men is higher than that of women (Zuckerman & Cole 1975, Vetter 1975,1976).

In addition, it is difficult for women to combine a scientific career with family responsibilities. Forty percent of the women who received their Ph.D during the years 1950-1960 were not married in 1973, compared to 5% of the men, and 25% of the married women were divorced in 1973, compared to 10% of the men (Vetter 1975,1976). Some women who have families tend to interrupt their careers and work part-time which clearly increases sex differences in rank (Zuckerman & Cole 1973). Also, the family's city of residence is selected according to the husband's occupation even if it harms the career of the wife who holds a Ph.D degree (Graham 1970, Keshket 1974). Having this picture in mind it was interesting to examine, analyze and compare the career patterns of women scientists, holding a Ph.D degree and employed at the Weizmann Institute of Science in Rehovot, Israel. This is a prestigious research institute in the fields of exact and natural sciences, which also has a graduate school awarding Masters degrees and doctorates. It is one of the eight institutes of higher education in Israel and has about 1800 scientists, engineers and technicians, including 350 faculty members, and approximately 500 graduate students.

METHODS

A list of all the women holding a Ph.D degree and employed at the Weizmann Institute of Science was generated from the scientific report of the institute. They were divided into groups based on departmental affiliation and academic, or non academic titles. In addition, a list of all graduates (M.Sc and Ph.D) of the past 10 years was received from the Weizmann Institute.
Fifty one questionnaires were mailed to all the Ph.D women at the Weizmann Institute. Visiting scientists and fellows were not included. Twenty seven of the Ph.D women (53%) responded to the questionnaire. The questionnaire included 27 multiple choice-type questions with regard to the

following variables : personal data, institution and age of graduation, tenure and speed of promotion, satisfaction and involvement in scientific work, scientific productivity and integration in the scientific community.

RESULTS AND DISCUSSION

I General data concerning Ph.D. women at the Weizmann institute

The women holding a Ph.D degree at the Weizmann institute of Science were employed in the faculties of biology chemistry and biophysics-biochemustry. None of them was affiliated with the faculties of either mathematics or physics. They were under-represented among the professors (4.6%) and associate professors (7.1%). Women represented 17.1% of the senior scientists - the highest academic rank prior to receiving tenure, which most of them do not achieve. A high percentage of women (48.1%) was represented in the non-academic track. It has to be noted that the percentage of women among recipients of master's (M.Sc) or Ph.D degrees from the Weizmann Institute during the years 1972-1982 was 42.8% and 23.3% respectively. Similar to the situation in the United Kingdom and the United States, the percentage of women faculty members diminishes when reaching the higher academic ranks. In the United Kingdom the percentage of women scientists among professors, senior lecturers and lecturers was 0.9%, 3.7%

and 7.6% respectively, while their percentage among Ph.D students reached 16.5% (Martin & Irvine, 1983). Data from the United States include women from different disciplines (Kashket 1974, Zuckerman & Cole 1975, Vetter 1976) and therefore the comparison of the figures is not accurate. Tenure at the Weizmann Institute of Science is usually linked to promotion to the rank of associate professor. As most women hold junior academic titles the percentage of Ph.D women with tenure is lower than that of men. Research done at U.S universities reveals a similar situation. It has been shown by Berger & Antin (1975) that the best predictor for tenureship is the academic title.

II. Data concerning Ph.D women who filled out the questionnaire

All of the 27 women of the study group were married, and all but one had children. Twenty three of them (88.9%) had two or three children. In contrast to data reported in the U.S., where only 44% (Kashket 1974) or 50% (Zuckerman & Cole 1975) of women holding a Ph.D were married, the Israeli scientists in the present study succeeded in combining a scientific career with family life.

The salary of the Ph.D women in the present group consisted of about half of the family income in 66.7% of the cases, and most of them (88.9%) were married to husbands with an academic degree. In the Weizmann

Institute of Science, as in all other Israeli institutions of higher education, there is no difference between the salary of men and women who hold the same academic rank. This differs from reported data for U.S women scientists who earn less than their male colleagues.

The average age at which the women of the study group received their degree was 24 (S.D. + - 1.6) for the master's and 31 (S.D. + - 2.7) for the Ph.D. This average age does not differ from that of their male colleagues at the Weizmann Institute. It is considered a young age for receiving the degrees, due to the compulsory military service in Israel. Rigid rules exist at the Weizmann Institute as to the number of years permitted to elapse between graduation (Ph.D) and appointment to the rank of senior lecturer, and the next appointment to the rank of associate professor, which is usally connected with tenure. Scientists, men and women, who do not follow these rules of the game have to leave the Institute. Therefore, there is no difference between men and women scientists in the Institute regarding the pace of promotion, unlike the situation described for the U.S (Vetter 1975,1976). On the other hand, these rigid rules probably explain the fact that only so few women scientists hold appointments as professor and associate professor.

Another set of variables deals with the attitudes of the 27 women of the group. An indirect question asked in order to understand their professional satisfaction was, if they

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had to decide now, would they have repeated the Ph.D studies. The answer was positive for 77.8% of the women. Most of those who filled out the questionnaire (74.1%) think that there is no difference between women and men scientists at the Weizmann Institute concerning the pace of promotion. This is in contradiction to reports for women in the U.S. universities whose pace of promotion is slower than that of their male colleagues in the same institution and same academic rank (Vetter 1975,1976). It is of interest to note that 80% of the tested group declared that they receive much, or very much support in their careers from their husbands. Similar results were obtained by Kashket (1974) for American women microbiologists. A remarkable finding in our study is that about 50% of the women scientists in the studied group rejected the possibility of leaving their position even if the career of their husband would force him to move to a different city. This proves the presence of high motivation, high involvement in their work and ambition. The situation for women scientists in the U.S is different. It was found that many of them join their husband in moving to a different city when his career requires it, although the woman's own career is being harmed (Graham 1970, Zuckerman & Cole 1975). Our study also included information about the scientific productivity of the Ph.D women in the tested group and their integration into the scientific community. In the sub-group of senior scientists, which consisted of 17 individuals, the number of scientific papers published by them in the past 5 years was 30.5 (S.D. + -18.2). A mean of 6 scientific articles per year is considered high, and is comparable to the productivity of their male colleagues (according to the Weizmann Institute's scientific report). An average could be calculated for this sub-group because they were a homogenous group regarding age and career patterns.

The criteria for integration into the scientific community that were tested in this study included membership in professional societies, number of research grants obtained and scientific meetings attended during a given period. There was a difference between the Ph.D women on the academic and non-academic tracks, as expected. On the other hand the sub-group of 17 senior scientists was found to be well integrated in the scientific community as judged by those criteria. Although they were all married and mothers to relatively young children there was no difference between them and their male colleagues, and this is different from the reports about women in U.S universities (Simon, Clark & Galway 1967, Reskin 1978).

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THE CSIRO: A CASE STUDY

Carmel R Macpherson

C.S.I.R.O.

THE CSIRO

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is the largest employer of scientists in Australia with nearly 3000 scientists. Of these, 250 are women. Of these 250 women, 67 are research scientists. This indicates the enormous under-utilization of women's skills and expertise in this country. CSIRO is a national organization with over 110 locations scattered throughout Australia.

In February 1984 the Executive of CSIRO endorsed 49 Recommendations of the Consultative Council's Sub-committee on the Status of Women. These Recommendations were designed to overcome systemic and attitudinal problems within CSIRO itself that militated against women being able to experience equitable employment conditions with men. A report by this group concluded that the level of perception of discrimination is so high that, even if some could be discounted as mistaken, it must be accepted that there actually is a high level of discrimination in CSIRO.

A systematic equal employment opportunity program is now being pursued in CSIRO and has resulted in a 68% increase in women research scientists and a 20% increase in women experimental scientists. Hopefully, these programmes will also result in greatly increased numbers of girls and women in the education system and thence as productive employees, working in fields for so long inaccessible to them.

To further this aim of increasing the number of girls continuing with science, CSIRO began a program called Women in Science. This involves female scientists visiting schools at the year 10 level to talk to girls about the need to continue with maths and science subjects.

In the first six months of 1986, the Project reached over 2,000 girls in 70 schools with a videotape and discussion sheet also being used in many schools where women scientists are not available to visit. With 90 women scientists and technicians involved, only a limited number of Australian schools can be covered. Most of these women are CSIRO staff but a proportion are from other areas such as tertiary educators.

Although this Project aims at only one time in a student's schooling, it was felt that this point of decision where subjects are selected for senior school was a vital stage and one where the presentation of role models could have a significant impact. Already, a number of schools have reported students changing course patterns because of the influence of the Project while others have felt that students had achieved a greater awareness of the opportunities available for tertiary education.

As with any active scheme, there are regular spin-offs. This Project has resulted in requests for women speakers at a number of other forums and the coverage given to the scheme in a forthcoming QUANTUM special to be screened on ABC-TV later this year will also promote a greater awareness of this issue.

The CSIRO Project is one method of encouraging girls to continue with their science and mathematics. However in isolation, it will have a limited impact and it is fortunate that Australian schools are also becoming aware of the barriers that have been limiting the participation of girls in these subjects.

In March 1986 the Executive of CSIRO endorsed an Equal Employment Opportunity Management Plan. Under this plan every person in the Organisation with a supervisory function has specific EEO tasks to

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implement. Every Chief of Division has an EEO Implementation Booklet that contains specific strategies to be implemented in their location. The Chief must report annually on progress achieved against each strategy. There is no doubt that this level of commitment in the public sector in Australia is beginning to provide fair and equitable opportunities for those females beginning to emerge in increasing numbers at the secondary and tertiary levels.

In CSIRO there was a very encouraging increase in female research scientists between 1983 and 1985 (28%). Overall, female scientists have increased by 68% as of June 1983 to March 1987. The same trend is apparent in other scientific designations. However, lack of permanent tenure is the major problem for female staff in CSIRO. All senior managers are required to produce 5 year plans for improving tenure imbalances in their work area.

The figures for 1985 indicated some worrying trends. For example, over 33% of all females in CSIRO are on term appointments, compared to 17% of males and 40% of all female Research Scientists are on short term contracts, compared to 13% of males. This imbalance of tenure extends throughout most other designations of the Organisation.

To become a research scientist in CSIRO, a PhD or equivalent is required. Yet in disciplines such as physics only 10% of all PhD graduates are women. Engineering has a female output of 6%. Once we move into the biological sciences the figures are healthier but still unsatisfactory. The majority of our recruitment pools for scientific vacancies have no women applicants. Not surprisingly, when women do apply they are usually successful. I say 'not surprisingly', because we are looking at a small, highly dedicated, ambitious and highly intelligent pool of women. For example;

- The Institute of Physical Sciences has five women research scientists compared to 257 men. Recent applications for appointment at research scientist level showed a ratio of women to men of 4:31, 1:8, and 2:9. In all cases the women were successful;

> The Institute of Industrial Technology has five women research scientists compared with 206 men. The number of women applicants for research scientist positions is usually nil, with occasionally one or two applying. A recent appointment of a woman resulted out of an applicant pool of nine, the successful applicant being the only woman.

Obviously female enrolment trends in the tertiary sector are of vital interest to CSIRO. A recent study titled "Women's Participation in Tertiary Education, a Review of Recent Australian Research" by Margaret Fowles concluded that concern over gender imbalance in different fields of study in higher education is not unfounded, but the pattern of women's participation has changed over the past decade to an extent that is seldom recognised. Female enrolments have increased in all fields of study, in both those traditionally considered 'masculine' and 'feminine' fields. In Colleges of Advanced Education, there has been a 24% increase in male enrolments in male fields, but a 185% increase in female enrolments in male fields. Male enrolments in male fields in universities have decreased, but female enrolments in male fields have increased by 52%. Thus, the ingress of women into traditionally masculine fields has far exceeded the extent to which feminine fields have become more feminised. These significant developments may be linked to differential changes in social acceptability of various fields of study.

However, gender imbalance by study area is still apparent. Factors which undermine women's participation in non-traditional fields are complex and interactive. On the home front, young women receive less parental encouragement than young men. Other subtle psychological messages are conveyed to women of proven ability in science and technological fields. Recent studies have shown, for instance, that females contemplating engineering as a career think they need to be superwomen to succeed, that male students often judge female engineering students less 'attractive' than their liberal studies counterparts and that male careers counsellors often advise courses of study according to their perception of the 'attractiveness' of the female client. Further, highly able women continue to be motivated by intrinsic interest in their subjects rather than by extrinsic rewards such as status and high pay to be gained from a course of study. It would appear that when higher education qualifications are not closely related to favourable employment prospects in high status occupations, then more general qualifications which attract many women are regarded as ineffectual. The 'human' aspects of subjects continue to draw women into traditional fields, into 'ghettos' of previously male dominated areas, and to lower status courses that suffer from funding shifts towards technological and applied science areas. Women may be thus disadvantaged on many levels by both traditional and non-traditional choice.

Women's choice of field of study and their career development are influenced, of course, by practices in the market place: women continue to face discrimination from employers through hiring practices; if they enter non-traditional jobs they may experience explicit discrimination in training and work as well as sex-role stereotyping which may lead to problems such as role conflict and fear of success. Positive self-concept may be undermined by their being regarded as 'deviants' from acceptable social roles. It is also interesting to speculate as to the extent women who are regarded as 'successful' in male-dominated areas have had to adjust their attitudes to those of men. Indeed, given all the factors which may hinder women's participation in non-traditional fields, it is surprising, in the light of the statistical evidence, that women have made the gains they have.

Concluding Comments

I believe that the CSIRO Board can be very pleased with the way in which its managers have risen to the challenge of implementing EEO throughout the Organization. It is an issue which is politically and industrially sensitive with a potential to either cause deep rifts within an Organization or to constructively (albeit at times painfully) help reveal existing flaws and aid in repairing them. Whilst it would be less than true to pretend that CSIRO does not have some people in its large workforce who feel very uncomfortable with EEO by far the great majority of all levels have given very active support. This has been particularly true of the Board and senior management at Headquarters.

EEO Contact officers appointed in every location have been of particular importance in implementing the EEO program and raising awareness. These people are selected from existing staff and given $^1/_2$ day per week to pursue EEO's Concerns.

Probably the greatest achievement in the past two years has been the management's ready acceptance of the need for better selection documentation and more accountability for administrative decisions. This has, in certain respects, been forced on the Organization through The Freedom of Information Act, The Administrative Decisions (Judicial review) Act and the various Anti-Discrimination Acts. There is no doubt, however, that better management practices have resulted.

Whilst it is very tempting to blame the paucity of the applicant pool for CSIRO's few women, this analysis has never explained why so few women appear in senior positions in clerical/administrative positions. The past six years have witnessed a huge improvement; however women in the Organization continue to occupy the shakiest and lowest rungs in virtually all designations. There is still strong evidence of very out-dated stereotyped attitudes towards "appropriate" female jobs. It is thus not unusual to still find no males/females being shortlisted for certain positions requiring, for example a large field work component, fine motor co-ordination skills or repetitive tasks. Whilst I believe that most of this occurs unconsciously, mechanisms must be set in place that enable all line managers to be in a position whereby they can be alert to such practices and eradicate them. The statistics in this paper indicate the continuing need for management to rigorously analyse its employment practices in order to satisfy itself, the Board, the government and the public that positive discrimination in favour of white males is not occurring in CSIRO.

Workshops on the Role of Women in Agricultural Production

Jan.- Feb.1987

Center for International Agricultural Development Cooperation
(CINADCO),Israel.

ABSTRACT

The article describes two international workshops held in Israel on the subject of the role of women in agricultural production.

The transition from a subsistence agriculture to a market-oriented one will result in an increase in agricultural production and export in the Third World countries. More food will be supplied to the local population, and it will provide the farm families and the country as a whole with more income.

Women in the developing countries perform most of the activities connected with the growing of crops on the family farm or as hired laborers on other farms. In most cases, they have the sole responsibility for the backyard farming and raising of livestock for the feeding of the family.

The pace of development of modern agriculture is dependent on advanced knowledge, skills, and appropriate technology which will reach the women who perform the tasks as well as the appropriate technological training of the youth who are the next generation of farmers.

The policy-makers must give more attention to this topic and increase the involvement of women in the decision-making connected with agricultural know-how and its transfer to the farm family and the organizing of supporting systemsand services which assist in agricultural production and marketing and the technological training of those involved in the process.

BACKGROUND

Increasing yields and effectiveness of agricultural production, especially in food crops, has been and remains a growing concern among policy-makers in developing countries. Women, a majority group worldwide, bear a heavy burden in farming, while also engaged in their traditional tasks. Agricultural production would be unthinkable without their toil.

The Nairobi Conference on the Role of Women in Development held in 1985 highlighted the growing importance of the role of women. Improvement of community and social services as well as health, the fight against illiteracy and the accession of women to education are only some of the strategies to deal with the problem. Increased participation in decision-making on agricultural production is another. In spite of differences in women's decision-making potentialities from one culture to another, a broad consensus is emerging, by which rural women should progressively become more conscious and effective contributors to agricultural development.

In Israel, agriculture has been characterized since its beginnings by organized types of cooperative and collective settlements.During all the stages of its development, women have taken and are still taking an active part in agricultural production, alongside men. Women are active in agricultural research, extension and cooperative movements both in actual work and in organization. Throughout its short history, Israel has known numerous obstacles: water and land scarcity, and absorption of successive waves of tens of thousands of immigrants from different countries. These refugees, lacking any prior experience in agriculture, had to be settled on the land. The role played by women in the "metamorphosis" of a people must be underlined, both on the production side and that of comunity organization. It may be worthwhile to study their experience, still an on-going process, which may benefit women in other developing countries.

OBJECTIVES

The participants will:

- Assess the role of women in Israel's agricultural and rural development;
- Analyze the factors that have so far inhibited their greater contribution to agricultural production worldwide;
- Suggest possible solutions to bring about the effective realization of women's potential in agricultural production;
- Prepare programs to promote the implementation of proposed solutions at local, regional and country-wide levels.

THE WORKSHOPS HELD IN ISRAEL

The Center for International Agricultural Development Cooperation (CINADCO) of Israel's Ministry of Agriculture and the Division for International Cooperation of Israel's Ministry of Foreign Affairs organized two Workshops on the Role of Women in Agricultural Production. One of the workshops was conducted in English and one in Spanish. They were held in separate locations (the English workshop at the Beit Ami Hotel in Natanya and the Spanish seminar at the Kibbutz Shefayim Guest House). They were both held from January 21 until February 11, 1987. Although the participants in both activities lived and studied at separate sites, there were a number of times that they met for joint lectures (translated into the appropriate language), field trips and sight-seeing excursions.

PARTICIPANTS

In the International Workshop on the Role of Women in Agricultural Production, there were 15 participants from nine countries in Africa, Asia and the Caribbean (Malawi, Swaziland, Ghana, Liberia, Philippines, Thailand, Sri Lanka, Antigua-Barbuda and St. Lucia). See attached lists describing each participant, his or her educational background and professional interest and home and office address, as well as the program of studies.

In the Seminario Internacional sobre el Rol de la Mujer en la Producción Agrícola, 21 participants from nine countries in Latin America (Bolivia, Brazil, Colombia, El Salvador, Guatemala, Honduras, Perú, Panama and the Dominican Republic), as well as Portugal attended. See attached lists for the program of studies, the participants addresses (home and office) and their place of employment, education and professional position.

The participants in both workshops had a common interest in finding ways to increase the involvement of women in the various aspects of the process of agricultural production.

THE PROGRAM OF STUDIES

The participants in the workshops visited and learned about the role of women in the following areas:

A. The Farm Settlement

Kibbutz, moshav ovdim, moshav shitufi, moshava, Arab village.
(kibbutz - collective settlement, moshav - cooperative settlement).

B. Supporting systems, organizations and institutes

Growers' organizations; regional agricultural council; purchasing organization; marketing organizations (Tnuva, Agrexco); settlers' movements (kibbutz and moshav); Ministry of Agriculture (regional laboratories, research stations, veterinary services); women's organizations.

C. The Formation and Extension of Agricultural Knowledge

Ministry of Agriculture (Volcani Institute for Agricultural Research, Extension Service); Ministry of Education (agricultural high schools), Hebrew University Faculty of Agriculture; women's organizations.

D. Field Trips to Study Agricultural Supporting Services in Various Branches

Flowers; poultry; fruits; vegetables; fish; algae.

IDENTIFICATION OF PROBLEMS

In the three working groups which held discussions, several common problems were identified:

A. Culture and tradition

Sex socialization and sexual stereotyping in children; unequal role of husband and wife; unequal treatment of husband and wife in religions; traditionally low esteem which women have of themselves; women who excel in so-called men's fields are considered weird, masculine or abnormal.

B. Financial/economic related problems

A lack/limited access to credit; stereotype projects for women; limited access to land; lack of appropriate technology for women; unequal income for men and women;women's jobs are not quantified; little research done on women's issues and concerns.

C. Education

Unequal educational opportunities at all levels; sex-oriented subjects in school which lead to stereotype jobs; inadequate provision for adult education.

D. Legal/legislative problems

Legal discrimination of women in such fields as inheritance, taxation, ownership and selling of property, divorce/separation, and labor laws; lack of participation of women in the formulation of laws; insufficient participation of women in government.

FINAL PROJECTS

The final projects provided solutions to the problems which had been identified. They included the following topics.

a. The English workshop

1. Three concluding working papers prepared by the participants in which they described the course and the lessons it held for them along with their recommendations.
2. Final individual projects on the following topics:
   - a) Livestock and poultry development program for "extension volunteers".
   - b) Training farm women in management and accounting.
   - c) Training women's leaders within the rural community in agricultural extension and home economics.
   - d) Introduction of subjects on agricultural technology in a women's university.
   - e) Nutrition and food production project.
   - f) Intensified cooperative education for rural women in agricultural production.
   - g) Development program for women rebel returnees.
   - h) More women's participation in the Southeast Asia Rural Social Leadership Institute (SEARSOLIN) training course.
   - i) Women leaders development project.
   - j) Improved extension services through leader farmers in animal husbandry.
   - k) Pest management in cotton production.
   - l) Improving the job and literacy skills of women engaged in agricultural production in Liberia.

m) Formal and non-formal education programs for women in non-traditional subject matter areas in agriculture.

b. The Spanish workshop

1. A concluding working paper prepared by the participants in which they described the course and the lessons it held for them along with their recommendations.
2. Four group projects dealing with the following topics:
   a) The role of the woman in the process of production.
   b) The role of the woman in agricultural extension.
   c) The participation of the woman in producers' cooperatives and organizations.
   d) The role of the woman as a planner and researcher.

CONCLUSIONS AND RECOMMENDATIONS

1. To inform the general public and governments concerning the role of the woman in the processes of agricultural production.
2. To encourage the women's organizations involved in agricultural production to take a more active part in solving their problems.
3. To increase the participation of governmental and other elements in promoting the advancement of women in the rural sector.
4. To encourage agricultural extension and training programs designed especially for women.

The Center for International Agricultural Development Cooperation is ready to exchange ideas on the topics mentioned and to provide further information to interested parties.

The address:

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Tel Aviv 61070, Israel.

FROM POETIC METAPHOR TO SCIENTIFIC HYPOTHESIS

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From 1976 to 1980 I worked as a researcher at the Research Institute for Applied Psychology, (RIAP); founded by Professor A.D. de Groot. The department in which I worked was concerned with a new type of research; namely 'action-research'. It was acknowledged that this type of research included elements of both fundamental and applied research.

In spite of research field orientation, I never really felt comfortable as a researcher. While I enjoyed conducting research projects, I always had the feeling I was researching the wrong questions. There was never time and indeed there were no adequate methods, to research the questions interested me. Four years later, the department was hit by budget cuts and I lost my job. I used the first six months after I lost my job, not to look for a new one, but to look at the questions for which there had never been time during my years at the RIAP.

I still had not found my answers when, in 1981 I joined the Adult Education Department of the Institute of Andragology. I was hired as a researcher for Women's Studies and it was in this capacity that I developed the program 'Female Learning'. It became clear to me that 'female learning' was relevant to both education for women and girls and the activity we call 'researching'. I was involved with learning theory as well as epistemology. In 1985, I wrote an article about girls problems with 'mathematical thinking', for the conference on Girls, Science and Technology in England. This brought me into contact with natural science researchers who turned out to have had experiences in their research career similar to mine at the RIAP. The similarities became even clearer to me when I heard the Finnish researcher, Satu Hassi speak at the First European Conference on Women, Science and Technology in Denmark in 1986.

"I had to overcome many problems in my work, but as long as you are strongly motivated, you can do that. The biggest problem for me was that I felt alone in my way of thinking. How can you justify your work if you see that the entire organization thinks in a way that is different from yours? First I was a design engineer' and later I was a 'research engineer' for a company. Two years were enough for me. When I left people said to me:'why are you leaving? People like you are exactly what the steel industry needs.'

I went to a technical university. I tried to start a discussion on the goals of technical education and research. I got no response. Four years were enough for me. When I left, an official at the Ministry of Education said; why are you leaving? People like you are exactly what the universities need!" Well, I've only got one life. (2).

I now expect that there are more similarities between my experiences as a social scientist and the experiences of women involved in teaching and researching The natural sciences; more similarities than I had originally expected. I am therefore concerned with the question of why so few women can last in (fundamental) scientific research.

I would like to use a 'metaphor' of a conversation between a professor and a female assistant as an example of my standpoint. The precise subject of the conversation has been left open and is symbolized by the letters x, z, g

In this way, the imaginary conversation could take place with either the natural or the social sciences.

It will also be clear that a real situation would not, like the x, z, g's of a mathematical equation precisely tally with the metaphor. This allows me to explore the possibilities of using a 'poetic metaphor' on the way to formulating a scientific hypothesis.

I ask the reader to determine whether she recognizes the situation represented by the imaginary conversation and to compare my interpretation of the situation with her own experiences.

A conversation between a professor and a female assistant.

Professor: 'This is the problem, let's see how we can tackle is.. if we start with x, then we can do z and g will be the probable result.

Assistant: 'But, professor, if you look at it from a completely different angle...

Professor: 'A completely different angle... hmm, that's an idea. Which one would you choose?"

Assistant: 'Well, a different one - I mean, you don't have to choose just one, there are so many...

Professor: 'But which one would you choose?'

Assistant: 'Why choose, I would like to try several at the same time'.

Professor: 'At the same time - that's impossible - we have to choose one.

Assistant: 'But then you influence the results and how can you justify that?"

Professor: 'By keeping to the rules of the game; we choose a starting point and if we find a result - we find a result-period. And if we start from another point we'll find another result and that's another result - period'.

Assistant: 'Yes, but what if you take a number of different starting points and use them simultaneously - what would the results look like?"

Professor: 'Science hasn't solved that problem yet, let's confine ourselves to what we know and not get lost in wild speculations.'

It seems as if the professor would like to confine the problem, as quickly as possible, within well-defined concepts; while the assistant believes this does not do justice to the complexity of the problem. The two scientists handle the problem differently. She wants the problem defined in all its complexity, while he wants to impose a certain order, first investigating one aspect, before he continues to another.

A similar difference in handeling problems arises within day to day communication between men and women and is not confined to scientific discussions.

The 'male' way of thinking seems be oriented towards reducing a complicated problem, as quickly as possibly, to a manageable 'part'problem. 'Female' thinking sees this as an unjustified attenuation of the problem and finds the eventual answers unrealistic.

The quick reduction of the problem gives 'male' thinking a head start over 'female' thinking. It is always 'faster', but for certain problems, this speed results in a loss of quality. Important, but hard to some aspects of the problem, are for the time being, put aside. The 'female' side of this phenomenon is that she often refuses to formulate the problem, because she sees so many aspects... Barbara McClintock too relates the quality aspect to the aspect of time. She remarked that when she told students to 'take the time to look', they answered that the tempo of recent day research makes it hard to adopt a contemplative approach. (3). I suspect that there was also another element in their inability "to take the time to look'. being open to the complexity of the problem and 'not knowing yet', implies uncertainty.

It seems as if the professor and 'male' thinking in general, are less able to handle this uncertainty than are his assistant and 'female' thinking. What is more, precise observation as advocated by Barbara McClintock, requires a certain degree of intimacy.

It is possible that McClintocks colleagues did not dare acquire this degree of intimacy to the research-matter and therefore were unable 'to see' as much as she did.

A third element in the 'inability' to take the time to look, is the concept of 'complexity'. The method which science has found to deal with complex systems is that of 'formal languages'. Every problem can be described within a limited formal language. Handling complexity often means: being flexible enough to switch from one language to another. It seems that 'female' thinking involves being able to think in different languages simultaneously. How to describe this ability within a scientific language is at present, still a problem. This is probably the reason that McClintock had and still has such difficulty in sharing the results of her research. Her strength is that she has the ability to simultaneously handle different scientific languages within her research in biology.

The Norwegian, Elin Kvande noticed that women at the Technical University where she conducted her research, were often guarded and anticipated that their answers to a question would be interpreted in a negative fashion. (4) Satu Hassi has already mentioned here her attempts to discuss the goals of technical education, ... with little response.

I now believe that the negative interpretation so many women anticipate, is due to their lack of self-confidence in their own way of thinking. They expect themselves to think, they do not see that their way of thinking is taken seriously, but that it causes their male colleagues and teachers to feel uncertain. The 'male' reaction is an expression of their inability to deal with the emotional pressure created by the 'female' approach to problems. Probably, these men find it unpleasant to spend any length of time in that diffuse and uncertain area of approaching problems.

We can 'rephrase' the discussion between the professor and the assistant, as follows:

The professor will be tempted to take refuge in concepts which his assistant deems 'too narrow' and therefore 'abstract'. He does this to be able to put a part of reality more 'precisely' into words. She resists this reduction and uses, in the professor's opinion, 'emotional' arguments. The arguments seem emotional, because they arouse emotional reactions in him She is, however, not yet able to put her 'wild speculations' into words and will indeed react emotionally when she does not get, or take, the time to precisely formulate her approach.

Abstract thought

In the preceeding paragraph, I described the professor's concepts as 'abstract' solving a problem in a scientific manner calls for a certain way of thinking, described as 'abstract' thought. In the last few years it has become increasingly clear to me, how my interpretation of this concept kept me from using it to solve problems. To my mind the concept of 'abstract' thought, was the equivalent of 'creative' complications. However, within the 'framework of scientific problem solving, abstract thought involves simplification of the problem. In the natural sciences this is done by choosing one problem out of a complex whole, preferably a problem which can be 'solved' using formulas. For a long time, I did not realize that this manner of ;solving' problems, left parts of the problem unanswered, but I associated this fact with the concept of 'abstract' thought. In other words, I was often unable to understand the problem's solution, because I did not realize that it was only a partial solution; that it did not cover that entire problem. I had the same sort of problem with the concept of 'generalization'. I thought that a generalization 'something general, which different objects had in common'. I now understand that what is involved is a specific 'part' aspect which different objects have in common.

Not only did I associate 'abstract' with 'difficult', I also associated it with 'distancing oneself' and 'impersonal thought'; placing it so outside myself, that I could no longer find a direction to start from. However, when I interpret it as not too intimate, but precise observation - of a part of the whole; abstract thought becomes much more accessible to me. Not only does scientific abstract thought become more accessible, but I find myself better able to understand abstract art. My dictionary defines 'abstract' as 'unrelated to the visible reality'. I can now see it as concentrating on parts of reality instead of on an illusionary whole. In this sense every work of art and every science is 'abstract'.

When I look at one of Picasso's paintings, I can still clearly see the relationship between the painting and reality, but now I am also able to imagine how another artist might have brought isolated elements, of his own reality together in one whole of art.

This construct can aid myself and others in making new, scientific discoveries. The crux of the matter, is comparing phenomenon in such a way as to be able to determine the common features. - recognition of certain aspects of one object in the other object. At the same time, perception of the difference is essential.

Where a difference arises or becomes visible - that is where thought begins. In this way, Barbara McClintock was able to learn more and more about the chromosomes of corn plants - by precise observation and looking for the differences in chromosome structure. On the basis of this, she looked for the possible causes of the differences.

If we can speak of recognition of one object in another object, then it is possible that this recognition does not stop at the perceived objects; but includes the subject. In other words, that which is recognized might be a 'part aspect' of the subject, recognized by its similarity, or differentiated from the subject by its lack of similarity.

It seems to me that even in such natural sciences as astronomy, knowledge is, partially, developed by comparing aspects of the knowing subject with aspects of the knowing object. I cannot imagine how you could know the 'totally different'; but then, it is true that until now, natural sciences have discovered those things which somehow resemble aspects of the knowing male subject; the scientist. This makes research into the 'metaphor' used within science relevant. The question is; to what extent can we discern a self-image of the subject in the 'metaphors' he uses to research an object? It is possible that some aspects of the 'outside' world are difficult to perceive, because they do not connect with aspects of the 'inner' world. In that case, it is possible that a woman researcher can acquire different insights than her male colleagues; insights based on her 'body knowledge' and her relationship to her body. Her male colleagues may not be able to perceive certain aspects of the 'outside' world because they cannot yet permit themselves the sort of intimacy towards self and other that is necessary in order to perceive these aspects. I know these are 'wild speculations', but they show me the way to preserve my intuition even if it is not immediately supported by my male colleagues.

The question is can there be partial recognition of the knowing subject in the to-be-known object? If there is, then this could serve as a starting point for researching a phenomenon, itself as well as in terms of the phenomenon within the observer. Is this not the way in which many scientific insights arise? They arise by way of the knowing subjects who formulates a concept, or hypothesis and then researches this hypothesis in an object.

Many concepts accepted in science are still hypothetical. For instance, the existence of a number of subatomic particles has never been proved, they cannot (yet), be 'perceived', but their existence 'fits' the hypothesis.

This point of view allows me to stop looking exclusively for abstractions 'outside' of myself. It gives me the freedom to use thoughts split off from myself as abstractions. By defining the self within scientific activity, I feel better able to do research and I am slowly developing the self-confidence that I missed during the time I worked at the RIAP.

With this I return to the failure in communication between the professor and his assistant. This failure can now be understood as the assistant not sharing the professor's abstractions (his formulation of part aspects. It can happen the other way round as well. For instance, after a role-play in which two men played a similar failure in communication between a man and a woman; the man who played the woman remarked, 'I never knew that women could talk about emotions in such an abstract way'. From that moment, I believed that the abstract language which is often attributed to men and the 'emotional-language attributed to women are expressions of the same phenomenon. They are expressions of the inability to express a situation in all its complexity, in concrete and specific terms.

The emotional language attributed to women seems to be directed towards different aspects of the problem than men's 'abstract' language. The emotional language seems to be more directed towards the relationship between parts, than towards the 'fixed' points within the problem. It is not easy to express these relationships within a scientific language.

At the moment, both men and women need to recognize their feelings of insecurity and uncertainty. For instance, during a scientific discussion, the assistant needs to know that the abstract terms used by her professor, are an expression of his uncertainty. She also needs to put the powerless feelings these abstract terms arouse in her on 'hold'; in order to be able to take the time to precisely word her own point of view.

When the professor's 'abstract constructions' include concrete formulations of the problem, remember that this is often only a tentative definition.

When, as a consequence of her feelings of powerlessness, she feels furious, she can leave 'room' for the professor's way of dealing with a problem by reacting with 'yes, that too', instead of 'no, not that'. In this way she acknowledges both her own and the professor's way of defining and dealing with problems. It seems as if concepts fulfill a different role in his thinking then they do in hers. For the professor concepts seem to be a starting point towards understanding a phenomenon; while for his assistant concepts seem to be an expression of finalized understanding - not a starting point but a last stop.

They can both try to recognize each other's way of thinking and based on this recognition, try to communicate in their own 'language'. I am planning to experiment with and research the ways in which one can initiate such communication within a scientific dialogue.

The assistant can try to say what she sees with greater precision; without being dependant on her professor's immediate agreement.

She can express herself with greater precision when she first describes the problem in a manner he would call 'diffuse'.

This implies that she has different needs when formulating a hypothesis and defining the problem. She seems to need a complex approach in order to reach a precise definition; while for him a precise definition is the key to understanding and a first step towards dealing with a certain amount of complexity. Barbara McClintock was only able to precisely word her concepts after she had taken the time to observe. She was surprised at the way in which her (male?) colleagues handeled a concept. She remarked, "Goodness, they're already calling it a ring chromosome plant, but they've never seen a ring and don't even know it? (5).

Epilogue

In this article I have used the terms 'women' and 'men' as well as the 'metaphor' of the professor and his assistant. This made it possible for me to place the questions I ask myself in a larger concept. It would therefore be wise to understand the term 'women' as 'women like me'. Just as the example of the professor and the assistant can serve as a 'metaphor', so the text too can serve as a 'metaphor'. Like a poem, it can be understood as an expression of my subjectivity. Once in black and white, this subjectivity offers the possibility of a more objective exchange of 'shared abstract thoughts'. In this sense the article is a 'metaphor' on its way to becoming a scientifically testable hypothesis.

The length of this article does not permit any lengthy remarks on another concept which is of great importance to me, namely 'dichotomes'. I need dichotomes in order to think clearly. Sometimes, the pair forming a dichotomy are considered to be almost mutually exclusive. I find it more useful to consider the concepts to be related; for instance, objectivity as an exceptional sort of subjectivity; abstract as an exceptional kind of concrete; and thinking as an exceptional form of feeling. 'Feminine' and 'masculine' are more complicated concepts. I try to regard and research the 'masculine' in a woman as an exceptional sort of 'feminine', but I do not know how things stand with the 'feminine' in men.

Ouderkerk 22 february 1987

Notes

1. See a.o. Renée Hablé, Wie maakt nou van een mug een olifant. Over de natuur en de kunde van een 'vrouwelijk leren', in: G. ten Dam e.a.(red), De-konstruktie van vrouwelijk leren, Rijksuniversiteit Groningen 1986.
2. Satu Hassi, About Loneliness, in: Contributions European Conference on Women, Natural Sciences & Technology, University of Aalborg 1986, pag. 553.
3. Evelyn Fox Keller, Heel het organisme. Leven en werk van Barbara McClintock, Meulenhoff Amsterdam, 1986, pag. 214.
4. Elin Kvande at the conference 'Kvinder og teknologisk Udvikling', Aalborg, august 1985.
5. Evelyn Fox Keller 1986, t.a.p. pag. 74.

THE CALIPERS DESCEND

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SUMMARY

It is generally agreed that the problems of a disproportionate number of women in Science should be met by an interactionist approach;patterns of growth have not been linear.

Identifying the problems has not led to their solution,although women's contribution to Science is now seen as a precious national resource.

Currently, there are no apparent restrictions on women entering the field,therefore the continuing disproportion must stem from deep underlying causes.

It becomes necessary to consider the mores of Victorian England with regard to women's place, when they were not only excluded from Science, but kept in place by its pronouncements.

The internalism of attitudes, responses and duties for women, necessary for the progress of bourgeois industrial capitalism was largely implemented by pseudo-scientific means.

The ideology was so robust, that the legacy of its cultural significance has persisted.

The disproportion of women in Science shows that they have not recovered from the descent of Leonard Darwin's anthropometric calipers. This paper proposes that the ideologically socially potent use of pseudo-science to define women's place in the nineteenth century, greatly contributed to the continuing disproportion of them in Science.

THE DISPROPORTION.

That there is a disproportion of women in Science can be readily seen from Government statistics. A recent enquiry counted three women from about two hundred and fifty Fellows of the Royal Academy of Science over twenty-five years.[1] In CSIRO only 24.4% of all staff were women and only 11.9% of experimental officers were women.[2]

In Australia, far fewer girls than boys choose Science as an HSC subject(excepting biology)[3], and fewer women apply to do Science at tertiary level.[4] In all states except Tasmania,less than half of the higher degree students are women.[5] Women who do qualify in tertiary fields either take supportive roles or lose security of tenure by leaving the workforce temporarily for domestic reasons. Structural discrimination leads to only a minority reaching areas of pure scientific research or decision making. Very few women are employed in Science at age sixty-five plus.[6] The pattern is self-perpetuating through lack of role models.

The broad statistical view of Australia is that from 1939-1960, the supply of scientists overall became inadequate. Two substantial Reports to the Government[7] led to a massive injection of funds and a growth of initiatives part of which was the consideration of the position of women in Science.

The longterm trend shows an increased participation of women since WW11 at all levels, but a continuing heavy inbalance of women at all levels.

Many economists believe that the entire direction and capacity of an economy depends on its technological base, therefore the wastage of women's ability in Science has become a subject for serious consideration.It has become evident that there is an uneven sex participation in Science in a minimal way from early years but that these minimal factors become progressively greater with regard to entry into the scientific community.

BEST COPY AVAILABLE

It became evident that a structural discrimination against women presented an anti-Science influence in many varied ways, any or all of which could be encountered by an individual in the course of their life. A developmental interactionist perspective therefore appears the most useful.

THE SCHOOLING EXPERIENCE

Image response experiments which I carried out in New South Wales show quite clearly that the overriding image of a scientist formed by primary children is of a white-coated male, often with robot like characteristics, usually involved in a violent experiment. Children's attitude towards Science is largely shaped during pre-school experience.

Investigation into areas of discrimination during schooling has revealed sexist language, sexist textbooks, peer pressure, especially with regard to acquisition of concept definitions, lack of role models, biased classroom interaction and the lack of a suitable syllabus.

An interactionist framework within the education system continually reinforces negative attitudes towards girl's participation in Science.

Although it is agreed that as a national policy, women should be participating equally in Science and that these problems are hindering them, identifying problems is a long way from solving them.

Few would argue, for example, that language is a powerful tool which can dominate, order and influence the individual, yet women, with limited access to education and literacy have had limited ability to influence usage and structure of language. It is male dominated and carries many implicit messages to women(Spender,1980)[8] The resulting pervading aculturisation not only contributes to a negative attitude in women, it cannot be eradicated overnight.

THE REAL REASON

This paper proposes that all the structural discrimination against women in Western society stems from the mores of Victorian England, where women were not only excluded from Science but kept firmly in place by its pronouncements.

Science has come to be seen as indivisible from the power relationships of its producers and in the social upheaval of the Economic Revolution, Science was outstripping religion as a major cultural force.

As society reshaped, the derivative notion of the natural hierarchical divisions of labour, governed by universal laws was firmly adhered to. The concept of the mental and physical superiority of bourgeois males became dominant. The apposite concept was the mental and physical inferiority of females. Rationalised and ratified by pseudo Science, these concepts merged with socio-economic interests and aspirations. Attitudes thrown up by bourgeois capitalism became internalised.

One of the most ideologically potent ideas was that of conceptual deficit in women.[9] The main thrust of Victorian anthropological theory was that body and mind are interdependent,that woman's senses were overdeveloped to the detriment of her intellect.

One of the strongest pseudo sciences which could be seen as effective against the dissent from the ideology of bourgeois capitalism, was phrenology. Attention was drawn to a German scientist, Carl Vogt, who 'proved' that the measurements of the female skull;

> '....approached in many respects that of the infant,still more that of the lower races.'[10]

Phrenological techniques involved long,meticulous tables,and hundreds of measurements for each skull. Delineated busts, skulls and charts lent credence.

Adherents ignored any logical problems of the supposed science and, ideologically motivated, concentrated on techniques and excluded rational judgement. The assumptions were welcomed, remaining relatively unchallenged for thirty-five years or so. This period coincided with the formation of the industrially modified social order.

Lectures were given,papers presented and societies formed. Phrases like 'having your head read' became common currency. Phrenologists were consulted about marriage and careers. The societies were mainly composed of doctors and surgeons,the remaining members coming from the newly formed bourgeoisie. Phrenology appropriately defined bourgeois hegemony and with its lack of complexity and accessability found fertile ground. Leonard Darwin's calipers descended on women's heads and 'proved' them to be mentally inferior.

Despite its illogicality,confused statistics and diametrically opposed conclusions, phrenology was not publicly attacked by an authority until the 1880's.[11] Most critics, culminating in Karl Pearson, believed in the usefulness of measurements but not in the ideology but many persisted in declaring that even more statistics and improved data must yield significant results. The belief in women's conceptual deficit had been given an insidious reinforcement. Their exclusion from Science had been indisputably justified by Science itself.

The extent to which phrenology had social,ideological and cultural implications can be seen by the sales of George Combe's The Constitution of Man,* which had reached 100 000 in Britain by 1868, and 200 000 in America.Darwin's Origin of the Species sold a mere 50 000 by the end of the century.[12]

Phrenology is a stark example of ideologically motivated Science,but a good one because of its cultural legacy. From 1815 to 1930, fifty-five million people left Europe,nearly twenty million of them from the British Isles.[13]

* A work which made phrenology respectable.

In America, Australia and New Zealand, they quickly asserted themselves. As forceful influences in their new countries, they bought their social mores with them: As writers,educators,teachers,politicians and in their everyday dealings with their families, they displayed the legacy of women's place in bourgeois industrial capitalism. These three countries and the United Kingdom are now all showing the same statistics regarding women in Science.These four countries are anxious to reinstate women and utilise their resources but understanding the legacy of Victorian bourgeois ascendancy is essential.

In 1860, Lydia Becker was asking;

> 'Why do students of Science among men greatly outnumber those among women?'[14]

She concluded that the disadvantages women faced in education greatly explained the phenomenon.

Looking at nineteenth century England with hindsight, Science appears far from a collection of objective facts about the world. It is so value laden that it is remarkable to read of the solemn support given to much of the pseudo sciences by the foremost authorities. It should also be remembered that the nineteenth century was a period of breathtaking scientific achievements in all branches of Science but the power of achievement lent its weight to the dubious sociobiology and anthropology which was ideologically produced and implemented so much to women's detriment.

Towards 2000 we are undergoing a much hailed 'cognitive revolution', where computers are being used to explore the brain in ways hitherto impossible. As national policies in the West strive towards scientifically literate women,literature is appearing in which empirical data from the computers is 'proving' women's conceptual deficit!

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In conclusion it can be said that there is a disproportion of women in Science in Australia and that this situation is seen as undesirable. The reasons for the disproportion are many and complex.The deep seated structural attitudes in Australia spring from the power shifts in the Economic Revolution,beginning in Britain,about 1790. The same pattern can be seen in the United Kingdom today, in America and New Zealand. The structure of the scientific community reflects the community at large.

Awareness of the problem has been followed by affirmative action of different types but progress is slow. There seems to be some failure to distinguish between symptoms and causes. Because discrimination is structural, it may appear in any one given area as insignificant whereas it is in fact powerful. An example of this is that women established in the scientific community rarely complain about their male colleagues. They work in harmony with them and many males ate openly supportive of their women colleagues. Why, then does the disproportion continue?

The following quote from Jonothan Cole's Fair Science, USA 1984, although reflecting research in the USA, holds true for Australia:

> 'Science is an almost exclusive male domain. This follows from a division of work which is reinforced by education. Women take care of the family. Men take care of progress.'

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3. Higher School Certificate Participation Rates,1984;

SCIENCE	F	M
Physics	2343	7003
Chemistry	3884	6309

4. W.Stern,The Supply of Australian Scientists in Vestes, No.27, 1983, No.2.p.16, NSW Institute of Technology.
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Tas.	51.16%	ACT	41.07%
Vic	47.5%	SA	37.16%
NSW	46.34%	WA	34.51%
Qland	41.95%		

Source:ABS University Statistics in Australia, Catalogue 4208.o.1982.

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GENERAL SITUATION OF GIRLS IN PARTICIPATION OF SCIENCE AND TECHNOLOGY ACTIVITIES IN CHINA

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Section One General Description

In China, children's science and technology activities are closely related to education in general. Science and technology education and activities are one of the most important portions in elementary education.

Education of the People's Republic of China has started on the basis of backwardness in economics and undevelopment in education in old China, and has overgone a tortuous path and persisting endeavor, then has made a considerable progress accompanying with development of economics.

Development of Elementary Education in New China

Girls Enjoy the Equal Rights in Education

On the eve of liberation, only 20 per cent of all children of primary school age were enrolled in school and 80 percent of the population was illiterate. Since the establishment of the People's Republic, the government has consistently emphasized the importance of the popularization of primary education and at present it has already become universal almost in the whole country. Aided by the popularization of primary school education, middle school education has also seen considerable development in recent years and junior middle school education has already become popularized in many of China's cities. There were more than 140millions pupils in primary schools and 55 millions students in ordinary secondary schools. In old China, women did not have much chance to attend schools. Now, not only their enrollment in schools of all levels and types has increased, but their proportion in the total enrollment has also increased. The stipulation of the fifth item in the Law of Obligatory Education of People's Republic of China is that every child who is full of six years must be enrolled to receive the obligatory education within the fixed years regardless of sex, nationality and race. It is illustrated that girls enjoy the equal rights in education is protected by the law. All the girls are same to all the boys in ordinary school life. They study science and technology knowledge as well as learn to read and to write and learn some basic knowledge. This is the constant and fundamental measure for children even for girls in participation of science and technology activities.

In order to meet the needs of the country's modernization programms, the Chinese government is currently in the midst of reforming its secondary educational system and is gradually reviving secondary technical schools as well as a variety of other specialized secondary professional schools. There are in the country 3728 secondary technical schools involving over 1.75 million student , 8180 agricultural and vocational secondary schools involving 2.56 million students. The number of students in variety of technical and vocational secondary schools makes up 37.5 per cent of the total number of students in secondary stage. There are different types of schools in the category of secondary technical schools such as : engineering, medicine, agriculture, fostery and business administrative etc.The contents of courses in these schools are more closely related to the practical needs in socialist construction. It is a professional stage for young people in participation of science and technology activities. The proportion of women students in the total enrollment has speedy increased in those kinds of schools. They will be primary or secondary technical and administrative personnels. Institutions of higher learning,,including universities, colleges and higher technical professional institutions have had an enlarged enrollment in recent years. About 600 thousands students who are graduated from senior schools are accepted as freshmen each academic year. Among them, 80 per cent study engineering, natural sciences, medical science, agriculture, forestry and etc. The proportion of women students is rather high. It is clearly shown that a majority of girls study considerably hard in science courses in senior secondary schools.

It must be pointed out that owing to the policy of birth control and family planning has been drew up as an essential national policy, each family usually has only one child, the majority of family has no son, therefore education of girls has been already emphasized from all sides. The young parents in many, many families have thrown all their energy into fostering and training of their only daughters, Girls have had much more chance in participation of science, technology activities as well as cultural, literary and artistic activities. The feudal idea of regarding men as superior to women has been started to pound. In all levels of schools, girls have showed their intelligence and talents day by day.

The Educational Policy and the Training Objective in China

The initial formulation of our educational policy is that : " Our education policy must enable everyone who receive an education to develop morally, intellectually and physically and become a worker with both socialist consciousness and culture. " (Chairman Mao Tze-dong) In recent years, it is supplemented that : " Education should be directed to the modernization program, the world and the future. " (Comrade Deng Xiao-ping)

Our training objective is that to foster and bring up the socialist constructional personnel who must be with ideal, moral standard, culture and discipline. Science and technology education has made a significant role in the process on fostering and training of these kinds personnel. All boys and girls without exception must study hard in the courses of culture, science and technology.

The Unified Curricula for Primary and Secondary Schools

The Unified Syllabus and Textbook for Each Subject

In China, the curricula of primary and secondary schools are unified by the State Educational Commission.

Full-time primary schools have a study period of six years. Each year there are 40 weeks for study. Curricula include ethics,Chinese, mathematics, natural science, foreign language (offered by schools with favourable conditions), geography, history, physical culture, music and fine art. A weekly number of 24 --- 27 class hours is scheduled for each grade.

Full-time secondary schools also have a study period of six years, divided into two stages, three years for junior and three years for senior. For each year 40 weeks devoted to academic learning. The courses offered in junior middle schools include Chinese, mathematics

(including algebra and **plane geometry**), foreign language, politics, history, geography, biology (including botany, zoology and physiological hygiene), physics, chemistry, physical culture, music and fine art. The courses offered in senior middle school include Chinese, mathematics (including algebra, trigonometry, solid and analytic geometry, essential calculus), foreign language, politics, physics, chemistry, biology, geo-science and physical culture. Geo-science is a new subject in educational reform, consisting the basic knowledge of natural resources,energy, environmental science, industrial production and distribution, agriculture production and food problem. Theory of population is also mentioned in geo-science, but it is actually an independent elective course in senior grade.

At present many schools have tried to offer courses on labour skills (including technical and vocational courses) in senior grades. In key secondary schools, students can take four class hours of elective courses, such as, advanced mathematics, computer science, astronomy, biological medidine, experiments of physics and chemistry and etc.

In junior middle schools there are 30 to 31 class hours each week for academic learning. The number is 26 to 29 class hours for senior secondary schools.

The unified syllabus and textbooks for each subject are also compiled by the State Educational Commission. Some kinds of experimental textbooks are allowed to use in educational reform.

Almost all classes in primary and secondary schools are composed by both boys and girls. Teacher teach and instruct them together. The academic reques'ts, exercises and homeworks in each subject are also same to girls as to boys. To summarize above, it is obviously to know that the Chinese students regardless of sex in primary and secondary schools study a lot of science and technology knowledge. The majority of girls seem to interest in science courses as well. They study even harder than boys and can obtain high scores both in ordinary examination and entrance examination of higher learning.

Varied and Colourful Extra-curricular Scientific Technological Activities

China's modernization requires a vast force of highly competent scientists and technicians,.While training such personnel in regular schools, the state pays more attention to organizing extra-curricular scientific and technological activities as an important means of coaching children in various branches of science. Their aim is that to supplement school education in practice and creative thinking, to broaden young people's horizon with up-to-date scientific knowledge, to develop their interests in science, to increase their ability, to mould their temperament and to foster their ideals, so that they will grow up to become an all-round reserve force in science and technology.

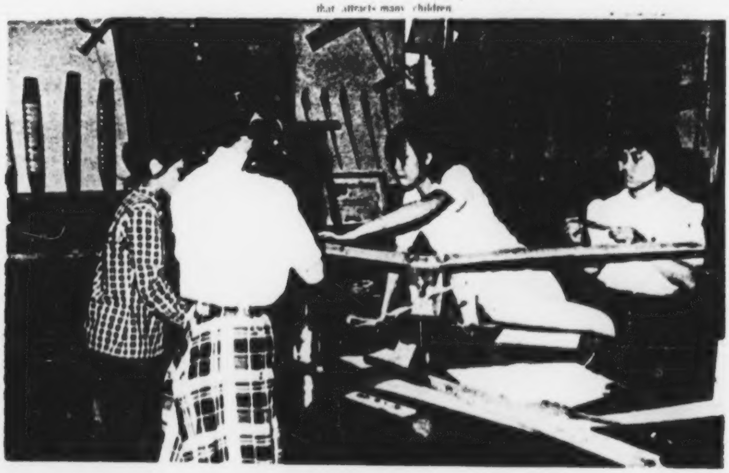
The leading group for the national children's scientific and technological activities is formed by the leaders from the CAST (China Association for Science and Technology), the State Educational Commission the Communist Youth League Central Committee, The State Commission of Physical Culture and Sports and the All-China Federation of Women. Owing to the leading group includes the leader from All-China Federation of Women the rights of girls in participation of scientific and technological activities has been granted by the organization.

The associations of children's science instructors were established in various parts of country. Their numbers totalling over 400 thousands are a backbone force in organizing children's scientific and technological activities. Most of children's science instructors are primary and secondary school teachers (including both of men teachers and women teachers). scientists, technicians, postgraduates and college students specializing in different natural science subjects who are enthusiastic about children's science education and coach children in their scientific and technological activities on a voluntary basis. There are 99 members of council in the second council of China Association of Science Instructors for Children..Among them 19 members are women, it occupies 18.2 per cent of total number.

To date, there are about ten thousand children's palaces, children's homes, children's activities clubs, children's science and technology halls and children's science and technology centers in China. These are the major centers of extra-curricular scientific and technological activities of children. The main organizer of each activities are the association of young science enthusiasts and the hobby group in and out of schools. In all activities, girls are welcome either.

Scientific and technological activities take place in many different forms. Among them are the science hobby group in and out of schools and the " Love Science Month "campaigns, survey tours and summer camp for young science enthusiasts, the exhibitions of scientific works by children and invention contests, science forums, IQ contests, contests in science subjects and contests of computer programing. These activities, which are highly popular with children (including girls) of all nationalities in China, have played an important role in popularizing science and technology, discovering talented children at an early age and training them into qualified scientists and technicians.

Making model planes and ships — an activity that attracts many children



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Section Two Some Typical Cases Study on Girls in Participation of Scientific and Technological Activities

Girls in Participation of Scientific and Technological Activities in a City

Shanghai is the biggest harbour city in China. It is densely populated and well-developed in industry, Its science, culture and education hold the lead over the country. While children's scientific and technological activities have been widely launched, SAST (Shanghai Association of Science and Technology) pays more attention to fostering girls' hobby and interests in science and technology, encouraging girls' desires and spirit in exploration. They organise " Love Science" activities specifically for girls on the International Working Women's Day, March 8, every year.

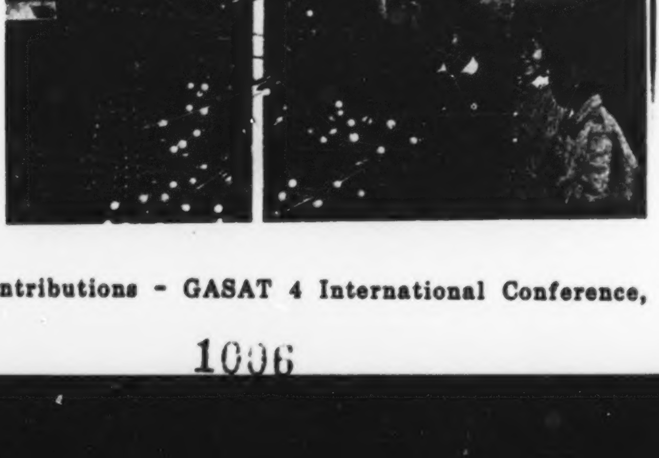
The principle and practice contests on assembling of radio set were carried out in 1982. There were 30 girls students won the prize.

In 1983, Forum on science was undertaken by girls. There were 140 girls submit their papers for the forum. The contents of papers included mathematics, chemistry, geo-science, biology, meteorology and etc. Many women scientists encourage girls students be resolved to modernization, be determined to improve oneself, regard for oneself and support oneself and do one's bit for vigorous development of China.

The microcomputer contest for girls was carried out in 1984. Over one hundred girls students participated the contest.

Owing to the initiation of SAST, such activities have been launched in several affiliated districts and counties in Shanghai and have given impetus to girls in participation of scientific and technological activities.

National fair of scientific works by children draws young visitors



Girls in Participation of Scientific and Technological Activities in a Middle School

Beijing No. 4 High School is one of the key schools in Beijing. It has had a long history of 80 years. In a long period, this school merely enrolled boys students, no girls were permitted to attend. Just twenty years before, the enrolment system has been changed. Both of boys and girls have been enrolled together. Now, there is one-third or two-fifths of total numbers of students are girls in each class. Since 1979, the school discipline has been returned to normal. All the students regardless sex study well and participate scientific and technological activities enthusiastically. All the totalling numbers of graduates about 200 --- 300 each year can pass the entrance examination of higher learning. Many girls have been among the best of the successful candidates. These excellent women students can retain their high records in advanced studies even in the famous universities. According to the investigation of graduates for four years (1979 --- 1982), the majority of good students of good character, both boys and girls have had the favourable opportunities to be accepted by research institutes. Top of them have gone abroad and have learned in America, Federal Germany, Japan and some other countries. We have followed with interest their achievements in future.

Scientific and technological activities in this school are varied and colourful. It was chosen as a national advanced unit of scientific and technological activities in 1982. There is a modern experimental hall in the newly built schoolhouse where has offered the favourable conditions in science teaching and extracurricular scientific and technological activities.

Under the direction and support of Unesco, the experimental item on technological education in general education was undergone in Beijing No. 4 High School during September 1982 to April 1984. It was undertaken in the elective courses which were astronomy and biological medicine to the students in first grade of senior. These two subjects are full of deep theory and wide practical value. The teaching outline and materials were written in both Chinese and English by superior teachers themselves. There were 80 students take parts in these two specific classes. Among them, girls occupied approximately 50 per cent which was slightly higher than the normal proportion. They took a great interest in studies of courses. They studied very hard in basic knowledge of astronomy and medicine although these were rather difficult for them. Girls were same to boys keeping the scientific spirit and following the scientific methods in experiments and practical operations, such as astronomical observations, manufacture of astronomical instruments, collection of Chinese herbal medicine, dissection of animals, culture of bacterial colonies and sterilization etc. The effects were considerably successful. The summer camp was organized by the specific classes in the campus of Beijing University in August 1983. There was a video-recording of summer camp activities which seem unnecessary to state in detail here.

An international consultative conference on technological education in general education which was organized by the section of science and technology and vocational education, Unesco was carried out in Beijing on April 2nd to 5th 1984. The specialists who were sent from China, Australia, India and Philipines attended the conference.

Girls' Activities In a Subject

Mathematics is considered as the foundation of all sciences.

Recently, there have been many, many mathematicians, psychologists, educationalists and school teachers over the world who have mentioned that the Chinese children and young people are eagerly interested in mathematics and display immense wisdom. It is same to girls who show their outstanding intelligence either. We recognize that extracurricular mathematics activities are easy to organize because these activities do not need any special facilities and instruments. Therefore, extra-curricular mathematics activities are one of the most interesting items for primary and secondary students. The participants are the most in numbers. The mathematics olympic schools have been sprung up like the mushrooms in many provinces and municipalties in China. Mathmatics competitions are varied, such as : Children's " Welcome Spring " mathematics invitation Competition, Children's " Hua Luogeng Golden Cup " mathematics invitation competition, the United Mathematics Competitions for junior and senior secondary school students. The studies on mathematics education, mathematics teaching, extra-curricular activities and mathematically precocious youth have been widely followed with interest by the majority of school teachers, psychologists, educators, specialists and researchers in various respects.

In 1986, some mathematicians cooperated with secondary mathematics teachers of the Educational Institute in Guangdong Province undertook an investigation and study on sex differences in mathematics learning of secondary school students. Their conclusions are similar to the research work of Dr. J. S. Eccles who is an American psychologistin the Michigan University.They considered that there is no obvious sex difference in normal mathematics learning, but the sex difference may be occured in geometry courses. Dr. Eccles indicated that the main sex difference may be caused by spatial skills.

In 1985, some psychologists in the Educational Institute of Shanghai Normal University cooperated with Dr. J. Sanley who is professor in Department of Psychology and Director of SMPY in the John Hopkins University of America took a study on mathematically precocious youth in Shanghai. They took SAT-M to 279 mathematically ablest youths who were thirteen years in age. Among them, 119 students are girls. Scores of Shanghai children were rather high as compared with the means of the 23995 able students tested in John Hopkins' January of 1985 annual talent search. We only take example of girls. Shanghai ranged from 460 to 750 points for girls with a median of 619 and 383 for U.S. girls. It is indicated that the lowest scoring Shanghai girls was 77 points above the mean of the U.S. girls and only 0.31 per cent of the U.S. girls scored higher than the median of Shanghai girls. There were 21 excellent students whose scores of SAT-M were over 700. Among them, 6 are girls, made up 28.57 per cent.

The 27th IMO (International Mathematics Olympiad) held in Warsaw Poland in July 1986. It was the first time that China sent the delegation to participate IMO. Among the six delegates there is a girl who won the second prize. It was rare in the history of IMO. She and her colleagues cooperated together and won the success with 177 high scores.

Girls' Successes in the Contests of Scientific and Technological Activities

The children's contests of scientific and technological activities are various in China. The National Contest on Scientific Innovation and Invention and Forum of Science have been held every two years. There were 23 works by children won the prize in the first time of the contest which held in 1982. Among them, there were 5 works made by girls. There were 12 works by children won the prize in the third time of the national contest which held in 1986. There were 3 works made by girls except 2 works which were made by group. The instrument of sector of angles was invented by a girl who aged thirteen years. She won the golden prize of " Good Youth Inventor " which awarded by WIPO, United Nations.

On the 13th International Exhibition of Innovation and New Technique which held in Geneva in 1985, the windbreaking device of chimney which was invented by a sixteen years Chinese girl showed good practical value to visitors. Many specialists paid special attention on it.

According to some references, we have learned that American children and youths of Chinese origin are head the list of successful candidates in some American science talent contest and American mathematics olympiad.The girls' successes have been gratifying as well.

Some Personal Views for Conclusion

In recent years, some studies by physiologists, psychologists and educationalists have indicated that there exists sex difference in function of brain, We must respect this innovated scientific phenomenun and reform education in accordance with one's aptitude and develop one's potential superiority of intelligence. It couldn't be said as the scientific basis on traditionalprejudice of " the respectfully the men, the lowly the women ". Whole society, all educators and all parents should offer the favouable conditions to develop girls' intelligence and talent, to make contributions for peace and happiness of mankind.

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RESEARCH AND UNIVERSITY TEACHING ON WOMEN IN THE ANCIENT HISTORY IN SPANISH UNIVERSITIES.

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The aim of this paper is to analyse a factor affecting the relation of women with science: the fact that very little or no importance is given to women as a historical group in research and teaching in the history depts. of Spanisch universities. We start from the premise that the teaching of History as the past experience of Humanity, plays a crucial role in establishing concepts such as how and why the forms of domination, submission, systems of power and their evolution exist, and to decide who their main protagonists have been.

The negligeable importance given to women in research and study at university level and the fact that women are not perceived as a specific group in History, leads athe one hand to a type of history teaching in Universities in which the androcentric model is considered as the centre point of History, with all the ideological implications involved for both men and women in their day to day behaviour and on the other hand the reproduction of these ideas and values at other levels of education.

History teaching in Spanish Universities, at least as far as its content is concerned still reproduces and reaffirms the traditional androcentric tradition[1]. We wish to examine the ancient period in Europe with regard to this and in order to do so, we shall analyse: 1) The ideological content of teaching about women, according to the historiographic trend wich have influenced this teaching. 2) The methodological treatment of research sources. 3) The present day situation of research on women in the Dpts. of Ancient History in Spanish Universities and 4) Some of the causes of this situation

This will be the first step to analyse a situation wich we shall then deal with in greater detail.

I.- An analysis of the historiographic trends wich have exerted a certain degree of influence on lecturers and researchers in the field of Ancient History in Spain leads us to draw the following conclusions:

1 The majority have excluded women because in their view, women contributed nothing to the process of History. This positivism-historicism wich has a long tradition in Ancient History in Spain rejects the theme of women and day to day life because interest is basically focussed on politics,institutions, the State, etc.[2] and in general on areas wich women in ancient times had no political rights and were not allowed to participate or make historical cotributions. The Annals School another influential historiographic school, also failed to deal with the theme fully despite appearing as a reaction to the limitations of historicist research It was to deal with the theme at belatedly a late stage and with a traditionalist interpretation[3]. Neither does historic materialism deal with the history of women as it considers social classes to be the driving face of history with women forming part of those classes in the same way as men without any kind of difference between them[4]

2.- Despite the principles which we have discussed, there is some information about women based on either partial or complete studies carried out throughout the 19th and 20th centuries Most of these concern so called "famous women", almost always because of their relationships with famous men (for example, women of the imperial house in the times of the Roman Empire, wives or mistresses of famous politicians, ...); or because their activities were considered to be male activities (queens war heroines), or because they stood out by possessing values considered to be either negative or positive by men (eg. beauty, goodness, faithfulness, unfaithfulness, ugliness). In this context we need only remenber the information -both real and fictional- that we have about Cleopatra, Livia, Messalina, Helen, Penelope, Dido, Their interest for historians has been exclusively related to the fact that they represented "pure" models, of either positive or negative values in the eyes of men[5]

Another area in which women appear in Ancient History is that of the family, especially with regard to the legal basis of the Roman family (although this is also the true for other societies during the ancient period). Nevertheless, the family tends to be regarded more from a legal point of view than from a historical point of view without taking into account either the relations of power existing within the family structure or the relations of production daily life, experiences and specific functions assigned within it. The family unit is generally considered more as a biological institution than as a social and economic relation in the corresponding historical constext[6].

We must also bear in mind the influence of other studies wich portray a partial or overall view of the life of women in the Ancient World. In this way, certain aspects

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of religion, love, prostitution[7], etc. are dealt with, although the methodology used in most cases is reduced to the mere paragraphrasing of texts. Furthermore, these studies are considered to be somewhat inconsequential, exotic, anecdotic and in any case only of use as references for other more wide-ranging studies.

The new historiographic trends concerning the history of women (developed in the U.S A. and some European countries) has not yet exerted sufficient influence to have an effect on university teaching in any overall although there are certain exceptions usually at postgraduate level.

3. These traditional conceptions and methodology have led to a dicotomy in the information about women in the ancient period, where such information exist. On the one hand there is the honourable woman who in the Ancient World is usually based on the Roman matron, guardian of the home, fertile and diligent and the perfect warrior's rest and on the other hand the more or less high class prostitute. Our view of these women is basically reduced to seeing then either at home winding wool or in brothels with the exception of course of famous women, as mentioned before. This dichotomy in the social role assigned to women, and wich incidentally is reflected in the work if the Greek and Roman classical authors, fails to deal with the situation of the vast majority of women: those belonging to the free sectors of society, but of humble origin and who cannot be identified with either of the two categories mentioned: the freedwomen and the slaves, that is the majority of the female population This clearly does not reflect the productive role of all these women, nor does it allow further nuances to be made regarding the prototype of the matron whose role in daily life as bing increasingly questioned That is, to date the theory has been that the social positions of women was determined by their history and, therefore by their relation with the family: either as faithful wife and mother, or as quite the opposite, the prostitute. When we find references to women's work, they morally merely list their tasks, without icluding them in the productive system of each of the different societies.

II.- As to research techniques and their teaching, we may observe how these are not used in a distint way to extract information on groups wich are not cleary defined on first reading, in this case, women. Precisely one of the arguments which are used to state that it not possible to approoach the History of women in the Ancient World is the lack of sources, since there are not direct records written by women themselves: the silence of the roman woman, as M I.Finley would say[8]. Yet strangely the history of other social groups or wich little information was available has been reconstructed (slaves, aliens settlers, farmers, etc.), and this has been considered essential for the understanding of the Ancient History of each community That is it is not a question of lack of sources, but rather of historic perspectives and approaches. Let us examine some of these sources and how they could be dealt with:

1. In ancient literary sources, there is one main difficulty: most of them are written by men, who project their dominant values through them. For ancient writers, women, their behaviour, lives and problems were not subjets to write about. Women appear in their historic writing when they do something strange, according to the norms established by the author's society (see information on women from N Africa, the Iberian Peninsula, Sicily, etc., whose ways of life were shocking to foreigners[9]), or when they do something which emphasizes the the exemplary values or behaviour of some male (see the narration of Scipio's experience with a young Iberian during the conquest of the Iberian peninsula), or at times when they are characters in fiction which respond to particular ideas or interests[10]. If these and other circumstances are not taken into account when dealing with literary sources in general, then no exact information on the life of women will be found.

2. Epigraphic sources are extremely important in the search for information on various aspects of the life of ancient women: religious, social, economic, ideological aspects, mother/children relations, etc.. This potential is not however usually pointed out nor exploted in historical research.

3. It is not, however a question of re-reading written sources alone. Similar re-reading of archaeological sources is also necessary, and indeed maximun benefit may be obtained from this exercise Traditionally, places and objets have been attributed to men or women on the basis of contemporary ideas, without taking into account that there many well have been diferences with respect to present day roles. It was, for example, very significant to discover that the person buried in the tomb of the Lady of Baza[11] was not a man, as had been thought on seeing the objets buried found with the remains, but rather a woman. This indicates that, in at least quite a few societies and periods, roles and attributes and their symbols differed from those of other times in history. The study of both domestic and funeral objects, their evolution, their spatial distribution depending on the sex of the person, influence and so on, may bring to ligth historical data which have not as yet been exploited Even spatial organization within a house, a settlement, a town may and should be analyzed from the point of views of men and women, rather than simply assigning public and private places to each of the sexes without any prior analysis. This re-reading of sources must be introduced into methodological studies if we are to lay the bases for a new type of research.

III.- Clearly, the situation we have described is partly a reflection of the little attention paid by Universities to research into the History of Women[12]. In the case of Ancient history, research into the history of women is still rare, and poorly considered in the 70's when the first influences began to arrive, and not until the 80's has timid though more aware contact been established with the subjet, due to wider foreing bibliography. This can be seen from a series of Master's and Doctoral theses and the work carried out individually by some women lecturers. Despite these efforts, the volume of research into the subject is small: there are no global research plans, nor coordinated projects financed as such, etc. The work wich has been carried out is the fruit of personal conviction which is gaining ground, either without the support or with the open opposition of the academic world. The number of publications is clearly lower some 4 or 5 books, and that of articles in periodicals only slightly higher over the last 10 years. Nor have interesting works on women in the ancient world been translated into Spanish: we can only find them in their original languages, and even then only in specialised libraries.

IV - The causes which have brought about this situation are very diverse, including political and ideological reasons or the state of feminism in Spain and so on. Let us examine some of them:

1. The length of Franco's dictatorship in Spain (until the mid 70's), which clearly implied both ideological rejection of women in any role other than that of wife and mother(the ideology of the Women's Section of Franco's National Movement)[13], and isolation from new trends which were arising abroad, etc..

2. Our rather weak feminist movement arose much later that elsewhere. The birth of the feminist movement in Spain could be dated in 1975, with the holding of the First National Symposium of Women's Liberation[14], and, although the movement has some influence in Spainish Society, it is not strong enough to change the structures existing in universities in the near future. Many women involved in the movement chose not to use universities as a platform for their demands even though they had the opportunity to do so. The influence of the theoriticians of the feminist movement also arrived in Spain much later than elsewhere: Simone de Beauvoir's "The Second Sex", edited in France in 1949, only reached us in 1962, through a translation published in Argentina. Similarly, Betty Friedan's work was not translated into Spanish until 1965, not to mention all the specific work carried out in other universities, part of it have been arriving gradually over the last ten years.

3. Low number of women working as universities lecturers and researchers. It is significant that in the field of Ancient History, where there are as many women students as men there are much fewer women professionals and their number falls as we go up the scale. The following are the figures for the permanent staff in Ancient History Departments in Spain:

Professors: 23 men, 2 women
Senior Lecturers: 65 men, 14 women.

The proportion for non-permanent junior lecturers is similar to that of senior lecturers It seems that men rise rapidly through the hierarchy until they reach the category of professor whereas women seem to spend years at each level, since society still considers that women are not the bread-winners of the household, which is the man's role, and therefore mistakenly sees the women's salary as a mere extra. Furthermore, women normally have to look after the house, have children and look after them, etc..

This would explain why there are so few women professors which is the academic category with most opportunities for carrying out research projects in decent financial conditions.

4. The traditional working of universities, their conservatism in many aspects, does not help the development of equality for women and their research. Proof of this situation is the fact that so few women occupy high-ranking posts of responsability in Spanish Universities(Chancellors, Vice-Chancellors, Deans, Heads of Departemts, etc..).

This vision of the situation of the history of women and the reasons behind it demonstrates the ideological reproduction in Universities of the domination and submission roles which affect women in today's society , with the peculiarities of our country Despite this, the situation has some prospect of changing, albeit slowly. Thus we see the strengthening of Institutes, Seminars and Centres for Women's Studies linked to Universities; the introduction of doctoral courses and seminars in women's studies, and on specific aspects in individual subjects(always depending on individual lecturers); the promotion of debates and meetings for women researchers to discuss methodology, specific projects, contacts and exchanges with women researchers in universities outside Spain, etc.

But this is only one way to set out on the road towards our aims

NOTES

1.- See **DURAN, M A.:** La investigación sobre la mujer en la Universidad española Comtemporánea Madrid. 1972: **MORENO, A.:** El arquetipo viril protagonista de la Historia. Barcelona 1986. **DOMINGUEZ PRATS, P.:** "La mujer en la enseñanza de la historia" in Nuevas perspectivas sobre la mujer Madrid 1982.

2.- **BARRACLOUGH, G.:** "Historia", Corrientes de la investigación en las ciencias sociales II Barcelona. 1981

3.- **FONTANA, J.:** "Ascenso y descenso de la Escuela de Anales". Hacia una nueva Historia. Madrid 1976.

4.- **CARDOSO, C F.S.-PEREZ BRIGNOLI, H:** Los métodos de la Historia Barcelona. 1977, pp 296-317.

5.- E.g.: **ASBIA, J.:** Les grandes dames romaines. Paris. 1958 **FERRERO, G.:** The Women of the Caesares New York 1911: **SAINZ DE ROBLES, F C.:** Mujeres inovidables de la Antigüedad Madrid. 1974

6.- **REVEL, J.:** "Masculin/Femenin sur l'usage historiographique des rôles sexuels" Une histoire des femmes est-elle possible? **PERROT, M (dir).** Paris 1984, p.125.

7.- See: **POMEROY, S :** "Selected Bibliography on Women in Antiquity" Women in the Ancient World. The Arethuse Papers. New York 1984 pp. 318 ss.

8.- **FINLEY, M.I.:** "Las silenciosas mujeres romanas" Aspectos de la Antigüedad. Madrid. 1975.

9.- **MARTINEZ LOPEZ, C.:** "La mujer en la España prerromana" Historia 16, nº 105.

10.- Ibídem: "Las mujeres de la península Ibérica durante la conquista cartaginesa y romana" La mujer en el mundo antiguo. Madrid. 1986

11.- Tomb of Iberian culture containing typical belongings of warriors (Vth.C b.C.).

12.- **SEGURA GRAIÑO, C.:** "La incidencia de la mujer en la ciencia histórica" in **DURAN, M.A.(ed.):** Liberación y utopía. Madrid 1982, pp. 103-108: **FOLGUERA, P.:** "Notas para el estudio de la historia social de la mujer en España", in

Nuevas perspectivas ., op.cit **CAPEL, R.M.-IGLESIAS DE USSEL, J.:** Mujer española y sociedad Bibliografía 1900-1984. Madrid. 1984: **SEMINARI D'ESTUDIS DE LA DONA:** La dona: repertori bibliografic (1970-82). Barcelona. 1983

13 - **CAPEL, R.M.:** "Historia de los cambios políticos y sociales en España" in **BORREGERO, C. ET ALII:** La mujer española: de la tradición a la modernidad (1960-80) Madrid 1986, pp. 17-28.

14.- SESM: **"El movimiento feminista en España"**; AMOROS, C : **"Algunos aspectos de la evolución ideológica del feminismo en España", both in** BORREGERO, C ET ALII, **Op.cit., pp. 29-40, 41-54.**

(Translation: Dorothy Kelly
Anne Martin).

Development of a Girls in Science Position Paper in South Australia

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SUMMARY

Report on the development of a 'Girls in Science' position paper in South Australia and of some strategies being used in schools to improve the participation of Girls in the physical sciences.

For the past two years there has been a Secondary Science Curriculum Committee in the South Australian Education Department called 'The Girls in Science Task Group'. This group consists of teachers from Government and non-Government Schools and science advisors and consultants.

In the first year a draft position paper on 'Girls in Science' was produced and trialled at a Conference of 40 teachers. This paper is now being prepared for publication and implementation in schools. South Australia is the first State Education Authority in Australia to produce such a paper.

In the second year this group has prepared support papers to the position paper on; Subject Choice and the Time-Table, Classroom Methods and Assessment, Curriculum Content and Its Implications, Careers in Science, Male Domination and Ownership and Case Studies.

This group has also acted as a focal point in South Australia to receive from teachers information on strategies being used in schools. It has printed information on girls in science in the State Science Consultant's Newsletter and set up a library of resource papers in the Curriculum Centre.

This paper will describe the processes of this task group and also include examples of science teacher action research conducted by teachers into girls learning and participation in the physical sciences in some schools in South Australia.

* * * * * *

INTRODUCTION

This is a report of the formation and work of the first Girls in Science Task Group in the South Australian Education Department.
Within the Education Department the Studies Directorate has the specific role of supporting students and teachers who are engaged in curriculum-at-work in schools. Its major functions by which the Studies Directorate provides this

support is by:

- curriculum communications, information and interpretation
- curriculum review, monitoring and evaluation
- curriculum development, design and renewal
- curriculum planning

Part of the action to enable this to happen is through curriculum committees. The Girls in Science Task group is a curriculum committee within the Studies Directorate.

HISTORY OF THE FORMATION OF THE GIRLS IN SCIENCE TASK GROUP

The rate of participation of girls in the physical sciences in South Australia is consistent with the world trend, the female:male ratio being 1:3. For several years this has been of concern to those science educators who are well read in the area of Girls in Science and also familiar with the work of such notable researchers in this area as Dr. Jan Harding. It was not clearly known how informed the Science Teaching Profession was on the issues of the rate of participation of girls in the physical sciences or if indeed some teachers were already attempting to address these issues.

In 1984 invitations were issued in the Education Department Gazette for applications for membership of a Girls in Science Task Group. More teachers nominated than could be accommodated. The composition of the eleven member group was 3:1 female to male and included teachers from Government and non-Government schools as well as a person from the Women's Studies Resource Centre. Most were teachers in the physical sciences. A science project officer convened this group.

From the beginning the enthusiasm for the task ahead and concern for the issue of Girls in Science was evident. Each member was keen and willing to work on individual tasks and the group soon developed into an excellent, coherent working unit, supporting, questionning and challenging each other's contribution. At first it was necessary to share experiences and research all the relevant literature available. It was essential that all were well read and informed in this field. After much discussion the following aim, goals and action plans were formed.

Aim: To increase the participation of girls in the physical sciences.

Goals:
- To effectively influence the science education of girls.
- To communicate strategies in a way which is understood and directly applicable.
- To support teachers undertaking research and development on this issue.
- To influence the pre-service education of teachers.
- To support changes in attitudes with regard to parents, teachers and the Senior Secondary Assessment Board of South Australia (SSABSA).

Tasks identified to achieve these goals are as follows:

- To produce a base paper on the science education of girls which is succinct and will provide direction for action.
- To establish a register of school based projects.
- To establish and maintain a central resource file of current research literature and resource material.
- To liaise with the R-7 Science Curriculum Committee, pre-service Educators, SSABSA, Equal Opportunity Advisers and Parent Organisations.
- To communicate with schools via newsletter broadsheets and through in-service conferences.
- To establish and support networks of interested teachers.

It is to the credit of this group that the first draft of the base paper had been put together by November 1985. Through the Science Consultants' Newsletter a register of interested teachers or those working on projects in their schools on Girls in Science was compiled. About forty of these people were invited to a conference to review, modify and clarify this first draft. The fourth draft which is now in the hands of the Publications Unit of the Education Department is written to these headings:

Section 1: Introduction
Section 2: The Nature of the Problem
- 2.1 What is the Problem
- 2.2 Background to the Problem
- 2.3 Causes of the Problem
- 2.4 Summary

Section 3: Effecting Change
- 3.1 Recommended courses of action
- 3.2 Recommended courses of action for Central and Area Authorities

Section 3:(cont) 3.3 Recommended courses of action for Schools
3.3.1 Provision of Information
3.3.2 Curriculum
3.3.3 School Organisation
3.3.4 Classroom Practice
3.4 Summary

In January 1986 we were fortunate in that the Convener of the Task Group received a scholarship to visit places and people in England who had worked for the past ten years on the participation rate of girls in the physical sciences. He returned enthused and with resources for the committee.

We were also fortunate to have Dr. Jan Harding visit South Australia to lecture and give workshops for a week in May 1986.

The base paper has been re-defined as a position paper under the policy paper 'Equal Opportunities - The Education of Girls in The South Australian Education Department'.

During 1986 one of the tasks of this committee has been to prepare support papers to the position paper. The first drafts of three of the following six have been completed:

- Curriculum Content and its Implications
- Classroom Methods and Assessments
- Careers in Science
- Male Domination/Ownership
- Case Studies

South Australia is a large, sparsely populated State and education is administered through five Area Directorates. The Science Consultants' Newsletters, sent out bi-monthly reach all secondary schools in the State. The Girls in Science Task Group developed its own logo and letterhead and places a flyer of information in each Newsletter. This has enabled communication with schools. Through this mechanism we were able to establish a register of interested teachers and school based projects. A report of Dr. Jan Harding's visit went to all secondary schools; information such as the proportion of male:female students taking Physics or Chemistry at Year 12 were given and strategies on how to determine the proportion of time spent with boys and girls in science lessons was described.

The resource library of the Teachers Centre now has a file of current research literature and support material on Girls in Science.

A letter has been sent to SSABSA, describing the work of the Task Group and expressing concern at the small amount of content related to societal issues and applications in Physics and Chemistry Syllabuses and the large amount of content in the courses. People are being informed on the preferred learning styles of girls and the teaching methods and assessment procedures which are favoured by girls.

An article on the work and beliefs of the task group has been written by members for 'PIVOT' - a magazine of the South Australian Education Department.

In 1987 this position paper is to be launched by a notable person from the Federal Parliament. A state wide conference will familiarise teachers with the paper and implementation procedures developed for action by teachers in schools. The Task for 1987 will also be to complete and publish the six support papers.

One Area network group of interested teachers has already been established; this was as a result of a day workshop held by a Science Adviser in that Area. It is encouraging to learn that slowly teachers are taking the initiative and using their own action research whereby they observe, reflect, modify and communicate with others. Some of the projects conducted by teachers with their classes have been

- gathering data on the time spent interacting with boys and girls or the number of times boys and girls initiate interaction. This can be done by taping a lesson or using an observer as a recorder
- gathering data in his/her school on the science subject choices made by students from Years 10 to 11 and from Years 11 to 12
- forming an all girls class in Year 10 science and monitoring their attitudes to science at the beginning of the year and at the end of the year. This project has been documented as part of a report on Science Teacher Action Research in the Southern Area. It was found that the confidence of the girls had increased markedly by the end of the year
- comparing the behaviour of girls in an advanced Year 9 mixed gender class with that of girls in a lower ability mixed class. The two teachers conducting this project came to the conclusion that the able girl was able to reach her potential in a mixed class and that the presence of the boys did not pose a 'threat' intellectually and behaviourally. To quote from the teacher 'Within a mixed class of Year 9 advanced boys and girls, it would appear that the girls

> display a most forth-right attitude and are every bit as demanding of my time within the classroom as the male element.' However, in the lower ability classes the boys displayed extremes of behaviour including extreme modes of chauvinism, whereas the girls, perhaps through social conditioning seem to appear to accept that their role in life is to cater to future male dominance. These girls benefit greatly by being placed in an all girls class.

In a time of reducing resources the South Australian Education Department has 'Equity' as one of its main priorities. It has therefore provided a project officer in science to work with the Girls in Science Task Force to ensure that the writing task is completed and that all science teachers have the opportunity to become aware of the issues of the low participation rate of girls in the physical sciences. Networks will be set up in each Area to ensure that teachers can share ideas and strategies.

South Australia is the first State in Australia to have produced an approved Education Department Position Statement on 'Girls in Science'.

* * * * *

TOO FEW WOMEN IN ENGINEERING: A Partial Solution

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GASAT was established to address the issues that exist internationally with respect to Girls And Science And Technology. In the United States very few women choose a career in the physical sciences or in engineering. Women comprise the largest untapped source of potential engineers and scientists to stem shortages in these areas of critical national need. Although efforts to increase the number of women in these career areas have met with some success, the number of women in the physical sciences, technology and engineering is still low. Only 15% of the U.S. bachelor's degrees in engineering in 1985 went to women.[1] Current estimates of the percentages of female engineers in the United States range from 5% (National Science Foundation) to 7% (Commission on Professionals in Science and Technology). There is no easy remedy.

The basic problems still remain. The low numbers are due to a lack of awareness of the opportunities for women in these fields and to general myths that still prevail regarding science and technical fields.[2] In addition, women usually need to be encouraged before they will enter these male-dominated fields for which they often have little background.[2,3]

As many as 85% of all American workers are dissatisfied with their jobs, according to the results of a recent survey. Words such as "hate" and "detest" are commonly used by these people to describe the way they feel about their jobs. Many of these discontents are obviously women, since 49 million women are employed in the United States today. Currently, about 70% of all American women between the ages of 25 and 54 have jobs.

By 1995 it is expected that this figure will increase to 81%.[4] It is a tragedy that so many people hold positions they feel lack adequate challenges, rewards, and pay.

Surprisingly, also, many of these discontents are professionals with college degrees.[5] Many female graduates find themselves dead-ended in a career after only a few years. In addition, many women graduate from college and are unable to find a job related to their degree. Some women have spent a period of time at home raising children and now find it difficult or impossible to obtain a position in the work force utilizing their educational background.

At the same time, many sectors of this nation's industrial base seek qualified technical professionals, especially in the fields of engineering and science.[5] In particular, there is a demand for industrial engineers and advanced degree engineers. Women engineers are zealously recruited as companies attempt to show good faith in the hiring of women. Women also have a unique viewpoint that is valuable to the field of engineering. Very few women engineers are in management. Only 7% of employed women in the United States work in managerial positions, and only 10% of these women managers earn more than $20,000 a year (the average male executive earns $30,836). Only 10% of all managers are women although women account for 69% of all white-collar workers.[6]

Most engineering graduate schools in the United States are seeking additional American students. U.S. citizenship is a requirement for graduate students participating in most joint government/university projects. Most graduate schools are seeking to increase enrollment, since with the increase in students also usually comes increased resources and the ability to offer a solid well-rounded curriculum. Since nearly 50% of all engineering PhDs are being awarded to foreign nationals, most of whom will return to their native countries, there is a high demand for engineering professors. An estimated minimum of 2,000 vacant engineering faculty positions exist in United States universities.

There is no quick cure for the low number of women in engineering, the dissatisfied woman worker with a college degree, the demand for women in industry, and the need for more American graduate students in U.S. universities. However, for the past five years efforts at Arizona State University (ASU) to help solve these problems have had encouraging results. A Graduate Reentry Program (GRP), established at ASU in 1982, has proved to be a "win-win-win-win" proposition. Now with its fifth class of students, the GRP has enabled women who were unemployed or employed in a non-technical field to enter a career in engineering. Program applicants were dissatisfied with their careers. GRP graduates have found challenges, satisfaction and rewards in engineering careers. Industry has hired program participants as interns and program graduates as permanent employees. In addition, the GRP at ASU has had a positive impact on the graduate program and its enrollment.

BACKGROUND

The need to encourage more women to study engineering was established in a previous paper.[7] In summary, more engineers and scientists are needed in the United States. Scientific and technical literacy is increasingly necessary in our society, and women need to become computer literate. Women need to be made aware that without an adequate mathematics background, they are eliminating the possibility of science or engineering as a career. Advanced education in science and engineering is a possible route for women looking to escape overcrowded, low-paying jobs with little challenge or reward. The demand for industrial engineers has not decreased since 1983.[7] The emphasis on productivity (higher quality, lower cost production) in American businesses has created a continuing demand for industrial engineers who have been trained in the latest techniques.[8] Specialists in Computer Integrated Manufacturing and Information Systems are in high demand.

The 1983 paper[7] also established the need for more women in engineering management and for more advanced degree engineers. The attractive salaries offered to engineers and to computer science specialists at the bachelor's level are discouraging most students from going on to graduate school.

ESTABLISHING A GRADUATE REENTRY PROGRAM

PROGRAM ASSESSMENT

Before any program can be established much preparation is needed. In previous papers,[7,9,10] the necessary groundwork was described. In summary, jobs locally and nationally in the fields of study of the program, local women students for the program, and an appropriate degree program in an institution willing to support a reentry program must all exist in order to establish a successful reentry program. In addition, local support for industrial internships should be identified.[5,11] Last, but not least, an individual must be available who is willing and able to direct the program.

PROGRAM PREPARATION

Two major problem areas of any reentry program are the background required of the reentry women and the financing of the program, especially funding for a director and some financial support for the program participants.[9] A year of preparation, supported by a National Science Foundation (NSF) grant, got the ASU program off to a good start. During this first year the primary activities included advertising the program, selecting the program participants, establishing a few "special" classes for program participants, and preparing the faculty for a group of highly motivated, mature, capable women graduate students. The program preparations and planning are discussed in more detail in previous papers.[5,7,9,10,11]

THE GRADUATE REENTRY PROGRAM

From 1976 to 1981, 53 grants were awarded by the NSF for Science Career Facilitation Projects. Approximately one-third of these grants were for projects in engineering. Very few of these projects are still in existence today.[12,13] In 1981 a grant was awarded to ASU for a Facilitation Project in Industrial Engineering to be housed in the Department of Industrial and Management Systems Engineering (I&MSE). The ASU program was the only NSF project in Industrial Engineering and the only NSF project known to have a master's degree in engineering as the end product for participants. Most projects focused on a year of technical retraining and updating at the undergraduate level or on preparation for graduate work.[12,13] Since the local high technology industry had a high demand for people with an engineering degree, the ASU project was designed as a graduate degree program.

Preparation for the Graduate Reentry Program in Industrial Engineering at ASU began in the summer of 1981. In June 1982 a group of 28 women formed the first class. These women had held bachelor's degrees for at least two years and had completed at least one year of calculus. In addition the women were unemployed in a technical area or underemployed in terms of potential.

Most students in the first class completed a 30 hour Master of Science (MS) degree in Industrial Engineering in 12 to 19 months. Students in subsequent classes have earned a Master of Science in Engineering (MSE) in Industrial Engineering in a 36 hour program with the option of writing an Engineering Report or taking a written comprehensive examination. In addition to three semesters of calculus, 23 semester hours of undergraduate coursework have been identified as essential to the background of students who wish to earn an MSE degree in Industrial Engineering. GRP participants are required to take any of these 23 hours, that they have not already completed, as deficiency credits in addition to the 36 hour program. Eight concentration options are available. Some students choose either Computer-aided Processes or Human Factors. However, most participants choose Information (computer) Systems as their area of concentration. Although Engineering Management is an option, it is not advised unless the student has had at least five years experience as an engineer. Since the women in the GRP do not usually have an engineering background, they are encouraged to stress technical courses on their program of study and then to supplement this core with management or management support classes such as accounting. The program is designed to prepare women for meaningful, productive and rewarding careers as Information Systems Specialists or other careers related to industrial and management systems engineering.

Although participants in the GRP are responsible for the same academic program as any other graduate student in the department, the program does give special support to these students. Perhaps most important to the actual survival of the participants in the GRP has been the peer group support. Friendships and study groups are very beneficial to the older career change student. In addition, occasional social events are held at the home of the director.

The GRP features a Professional Development Seminar. The Seminar, usually held bi-weekly, includes speakers from industry, the on-campus Office of Career Services and GRP graduates. Through the NSF grant and then an Exxon Education Foundation grant, tuition support for an academic year and a summer was available to the first four classes. The main feature of the program, however, is the option of a paid half-time industrial internship while attending classes for the master's degree.

The GRP has gone through several changes since the first group of students began in 1982. The first group of students completed a 30 hour MS degree with only 14 semester hours of undergraduate coursework identified as essential preparation for the program in addition to calculus. As mentioned previously, subsequent groups have completed a 36 semester hour MSE degree program with 23 semester hours identified as necessary background material in addition to calculus. The program now includes men as well as women, although to date only 7 participants have been men. Part-time as well as full-time students are included in the program. Several participants began the program as part-time students and then completed their academic work as full-time students. Tuition support is no longer available. The positive reception upon graduation of the program participants by industry has been proof that the program is producing a good product.

The GRP is now being given a new image. The program name has been changed to Graduate Career Change Program. "Reentry" is a word primarily associated with women's programs and perhaps with older, unskilled, dowdy, rusty-brained housewives. On the other hand "career change" has a professional ring which applies equally to men and to women.

PROGRAM IMPACT

IMPACT ON LACK OF WOMEN ENGINEERS

Most women are not aware that they can pursue a graduate degree in engineering even if they did not obtain an undergraduate degree in the field. The general myth still prevails that engineers work primarily with concrete and steel and very little with people. Without encouragement, very few women with a non-engineering degree will pursue a career in engineering .

Most efforts at increasing the number of women in engineering have been directed at the high school or junior high school student. Young women have been informed of the opportunities available in engineering and encouraged to keep their options open by studying as much mathematics and science as possible before attending college. The goal here, obviously, is to increase the number of women who will obtain undergraduate science and engineering degrees.

However, another group of women exist for which recruitment efforts are also worthwhile - women who have already completed their undergraduate studies. Through GRP advertisements in newspapers, magazines, on radio and TV, presentations by the director, and word of mouth, many women have been made aware of opportunities available in an industrial engineering career.[10] In particular, these women learn that industrial engineers, in general, are people-oriented, problem solvers. Most women are aware that many high tech careers are linked to computers in some way. Most women are not aware that a graduate degree in Industrial Engineering with a concentration in Information Systems can lead directly to a career as an Information Systems Specialist.

The director of the GRP has informed over 1000 women in the past seven years about the opportunities in Industrial Engineering. The women were told what preparations were needed to enter a graduate program in engineering and also encouraged to try the degree program. The women were also informed that since they had been able to obtain an undergraduate degree, they also have the ability to complete the required calculus courses.

It is difficult to characterize the type of woman who is attracted to a career change program. GRP participants have ranged in age from 24 to over 50. The average age of the first group was 35, while the average age of subsequent groups has been in the early 30's. The bachelor's degree had been earned in mathematics, education, biology, chemistry, physics, agriculture, psychology, or English among others. Many of the first group were tenured high school mathematics teachers. Half of the first reentry class already had earned one master's degree. About one-third of later entering classes already held a master's degree. Approximately half of all women participants are married; many of them have children. Several participants spent a year or more completing the necessary calculus courses before entering the program. Almost all in the GRP can be characterized as mature, capable and highly motivated. On the average these women had more than 30 years left for a worthwhile career and they felt that it was worth their efforts to complete this program.

To date, 64 of the 71 participants in the program have been women. Thirty-five women and two men have received their master's degree. Eighteen are still continuing their studies. At least forty participants (two men) are in the work force. Four women who are working have finished the program except for the completion of a final Engineering Report. Three of the original 71 participants switched to other graduate programs.

Twelve participants dropped out of the program and graduate school. Most of these women continued with their teaching careers.

The women in this program are themselves serving as role models for other women. Several women have begun to pursue a graduate degree in engineering after meeting GRP participants in their deficiency classes or GRP graduates on the job. The "critical mass" formed by these graduate reentry women has probably been instrumental in the retention of other graduate women. The daughter of one program graduate has declared that she now wants to become an engineer! Two GRP graduates are now pursuing PhD degrees in engineering; they may eventually spend some time as professors in engineering schools, serving as role models there, encouraging more young women to complete an engineering degree.

The GRP at ASU is not dramatically increasing the number of engineers in the United States. It is, however, having an impact, along with other Career Facilitation projects,[12,13] and is part of the solution for increasing the number of women in engineering.

IMPACT ON CAREER CHANGE

A college degree does not guarantee a satisfying career. Many college graduates hold positions they feel lack adequate challenges, rewards and pay. Some college graduates are not able to find any employment related to their major. A career change is needed; however, most people find such a change very difficult to make.

The loss of job security and salary and a lack of confidence to succeed in a new career are probably the greatest stumbling blocks to overcome for a woman or man considering a career change. If full-time graduate school is necessary for the career change, finances become a critical issue. Satisfactory employment cannot be guaranteed upon completion of an advanced degree.[5]

The Graduate Reentry Program provides a solution to the above concerns. The tuition support available from grants for the first four classes helped with finances. A $1,000 "Women Helping Women" Scholarship provided by local businesswomen has been awarded in each of the last three classes. Paid half-time industrial internships are also available. In addition to providing some financial support while in graduate school, the internships help the students gain confidence in a new career and aid in job placement. Graduating interns are often hired full-time by the host company.

Support from other women in the program also aids the career change process. "The willingness of the women to help each other with classwork and also emotional support" was identified by many participants as an important feature of the GRP. The participants experience new friendships and a supportive "network". Occasional socials, sometimes with spouses, also serve to strengthen the bond of mutual support in the group. The program director, faculty and staff have also been cited by the reentry women as an additional support system. The program director serves as the academic adviser for each program participant and is also available as a counselor.

The program's Professional Development Seminar is also designed to aid career change.[10] Speakers from campus and industry give talks on resume writing, interviewing, and choosing a company. Speakers from industry inform the participants of job opportunities available in industrial engineering. Program interns report to the group on their internships. Program graduates return to give encouragement and survival tips to current participants. These graduates also speak about their companies and their new career roles.

During the last seven years over 800 women living in the ASU area have inquired about the GRP. Most of these women had a college degree and all were dissatisfied with their jobs. Some of these women had had calculus and other science and mathematics courses in college. They welcomed the opportunity to build on this knowledge and to learn more about computer systems. Since only a very few of the women inquirers were unemployed, for most women the next step was then the difficult decision to leave a job and to attend graduate school. Several women who had been contemplating a career change for several years exclaimed that it was as if this program had been personally designed for them!

Other women who had had little or no mathematics at the college level, learned that they would have to spend one or two years studying mathematics before they would be eligible to apply for a graduate program in Industrial Engineering at ASU. For many this appears to be too difficult or too high a price to pay for career change. Others have decided that to spend even three or four years of effort now in order to change to a more satisfying career for 30 or more years is well worth the effort. Some of these have been willing to secure loans to finance their schooling as an investment in their future. Several women have chosen to study the necessary mathematics part-time while continuing in their present jobs before joining the GRP full-time. Women who have made a commitment to the GRP by resigning their positions have not only survived, they have graduated and have found employment related to industrial engineering.

Several women participants who were not willing to quit their present jobs decided that the program was too demanding. Many of the 12 women who dropped out from the program did so after the first summer of classes; most were school teachers who had not yet resigned their tenured positions. After a demanding summer schedule of classes, the teaching profession looked much better to them. A couple of the teachers who left the program were also near 50 years of age. It had been a long time since they had had their calculus classes and they determined that at their age they did not wish to continue. It is hoped that through this experience these teachers will now be more satisfied with their very valuable profession. Three program participants transferred to other academic programs after a short time in this one. It is assumed that their participation in the GRP was at least a first step toward a positive career change. Due to improved screening, based on experiences with program drop outs, very few program participants in the last groups have chosen to leave.

To date, 40 program participants and graduates have made a career change. Most have found a rewarding and challenging career directly related to their graduate study concentration. For a few, the engineering degree enabled them to get the type of job they sought, even though the work is not directly related to their degree. For most, the career change has also meant a substantial increase in salary; for some, almost an immediate doubling of salary. It should be noted that inquirers desiring a career change who were already making a good salary in a technical or related field were encouraged to do graduate work, but were not accepted into the GRP while tuition support was available.

The participants have come from varied educational backgrounds and careers. Many of the participants were teachers. It is not the goal of this program to recruit teachers, especially mathematics and science teachers; however, if a teacher is burned out and determined to change careers, then this program is available to aid them. A third grade teacher who determined to change careers spent two years in preparation for the program. She taught herself intermediate algebra and then took mathematics courses through calculus in the evenings while she continued teaching. At last she joined the reentry program, admitting that this was the first project she had ever tackled without being confident of success; but, succeed she did. She worked on a sponsored project with a faculty member while in graduate school and graduated with top grades. She was hired by a local high tech company and is considered an exceptional Information Systems Specialist.

A career change was made by a second young woman who already held a master's degree in agriculture. The only job opportunity available in her area of specialization was in a remote region of the nation. This woman interned locally and upon graduation received two job offers. She is now eagerly applying her newly acquired skills.

A third reentry program participant was able to change careers from hotel sales secretary to marketing computers. Her new graduate degree enabled her to be hired as a trouble shooter for computer problems. From this position she was able to make the transition to marketing which had been her goal. A high school music teacher had difficulty finding jobs as she followed her Air Force husband from base to base. While he was stationed near ASU, she entered and graduated from the reentry program. After moving to the next assignment, this graduate found employment as an Information Systems Specialist. She has been the only civilian and the only woman on team projects. She is now beginning studies for a PhD in Industrial Engineering while retaining her employment.

The oldest graduate to date, at age 52, completed her studies and then was employed by a high tech company in another state. The program was not easy for her and she had to repeat and review several courses in order to have an adequate background to survive in the program. But, she now feels that all the effort has been worth while to change from a night medical technology supervisor to that of an Information Systems Engineer. Another graduate of the program had been discouraged from studying engineering as a teenager. Thirty years later she fulfilled her dreams and graduated from the program with an MS degree in engineering.

When asked to give an overall evaluation of the Graduate Reentry Program, one graduate wrote, "What can I say? The opportunity of a lifetime." Another wrote, "It was exactly the opportunity I needed to accomplish a career change. I would not have been attracted to Industrial Engineering as a profession otherwise." "The program offered me an opportunity to pursue a new career and to end an unhappy, unfulfilling previous career," another graduate stated. "I truly appreciated the grant from the National Science Foundation, without which I would not have been able to pursue a career change." Other comments included: "Excellent," "My new job!" (as the best feature of the program) and "The program is an excellent opportunity to completely change careers."

In summary, a graduate wrote, "It was a great program that offered an opportunity not otherwise available. It gave women a feeling of importance, confidence, and professionalism not there when the program began. It was a challenging program, but not too difficult to be accomplished. The extras, internship and professional development seminar are what make the program."

Program degree candidates are doing well in industrial internships. Program graduates have been very successful on the job; their titles include Information Systems Specialist, Production Control Engineer, Data Analyst, Facilities Planning Engineer, Information Systems Engineer, Operations Analyst, Production Systems Engineer, Industrial Engineer, Systems Engineer, Business Analyst, and Development Manager. The women have gained the confidence and the ability to change to a career that pays well and is challenging and rewarding.

The ASU Reentry Program has had other rather far-reaching positive impacts on the problem of career change for women. Based on this program and on presentations given by its director, career enhancement programs have been instituted in Canada.[14]

IMPACT ON INDUSTRY

Good qualified engineers are always in demand by industry. Information System Specialists knowledgeable in data base development and management, a systems approach to computer systems, and other related computer management skills are in high demand. Often important projects exist in industry, but are not completed due to lack of adequate manpower. In addition, a company may be experiencing a hiring freeze. GRP interns and graduates have provided a solution to part of these problems in several companies.

The GRP Internship Program differs from the usual Engineering Cooperative Program.[5,11] A co-op program usually provides an undergraduate student with the opportunity to alternate full-time studies with full-time employment for a semester or a summer. On the other hand, the GRP intern works half-time in a paid position within industry or an agency while continuing studies as a graduate student; therefore it is necessary for any participating industry to be within a reasonable driving distance from the student's residence and the university. A large high tech industrial base in close proximity to ASU provides an ideal setting for an industrial internship program.

Managers of companies retaining interns have given the interns top reviews. They have found the women to be highly motivated, mature and capable. Since the participants in the GRP were preselected and most made a sacrificial investment in terms of money and/or job position to return to school, the reentry intern is a very dedicated individual. The student is well aware that a good internship experience may lead to a permanent position with that company. At the very least, the recommendation on the internship will be instrumental in securing a position with another company. The company acquires the intern with a minimum of recruiting costs and no moving costs. The establishment and administration of an internship program have been detailed.[5,11] Although there is no obligation by the company to hire, nor commitment by the interns to accept employment with the intern company, about a third of the interns have found permanent employment with their host company.

Companies have been able to receive help from an intern on short term projects for which permanent personnel were not available. Several internships were established with the understanding that no permanent employment would be available at its conclusion. An example of such a short term project was that of an intern who worked with a computer system and brought in outside help for a few days to complete an inventory process in three days. This inventory process had previously taken three months each year. Within two months two other interns in an information systems setting became the experts in that area and were able to solve important problems that had been plaguing the agency. Another intern set up and documented a computer program to maintain an up-to-date inventory of the parts used for certain products.

An added benefit for some agencies is that since the intern need not be an employee of the company, the head count is not affected. Some company managers find that although there is a hiring freeze, there are still funds available for temporary help or for donations to academia. In most internships the student remains an employee of the university as a research associate. Since the payment or donation to the internship program should be income tax deductible, and no fringe benefits need be paid, a company receives a competent worker and prospective employee for a most reasonable investment. No paperwork is required by the company other than an initial letter of intent to the GRP director to retain the intern. The company has the unique opportunity of being able to observe a worker for several months and then to hire only if it is in their best interest to do so.

A continuing benefit for a company participating in an internship program is the on-going tie to the university. Through the internships, other students are made aware of the job opportunities at the participating company and become a source of future employees.

To date, 35 GRP students have interned; most in industry and government, some in projects or computer labs on the university campus. Approximately 15 different companies have retained interns. Some agencies required one intern for the completion of a project; others used two interns to complete a project. One company has found the interns of such value that, to date, nine internships (most for two semesters duration) have been made available. At present nine graduates of the GRP are employed at this company; three of these hires interned elsewhere.

Forty graduates or participants in the program are now working in industry, most of them in technical positions related to their graduate studies. The women report that their jobs are rewarding, challenging and satisfying. Although many are working in the ASU area, graduates are now employed from California to Rhode Island. None of these women were employed in a technical area when they entered the program. They have become a part of the solution for a portion of industry.

IMPACT ON THE GRADUATE PROGRAM

The Graduate Reentry Program has had a role in revitalizing its host department. Through the program and its participants, the graduate enrollment has increased, the department and its programs have been advertised, the professors challenged, and much needed capable assistance for faculty on contract projects has been provided.[10]

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A master's degree program in Industrial Engineering for those with a non-engineering undergraduate degree has been in place for many years in the I&MSE Department at ASU. However, very few women had enrolled in the program or had obtained this master's degree until the GRP was implemented in the summer of 1982. Not only did the number and percentage of women in the I&MSE graduate enrollment increase dramatically with the Reentry Program, but initially the overall graduate enrollment was increased by an amount almost equal to the number of students in the GRP.

The effect of the GRP on the graduate enrollment is seen on the following table:

I&MSE Graduate Enrollment, ASU

Fall	Women	Total
1980	7 (10%)	71
1981	13 (13%)	98
1982	45 (35%)	129
1983	55 (38%)	143
1984	42 (35%)	121
1985	45 (32%)	144
1986	37 (22%)	173

In 1982 the 28 reentry women (most of whom enrolled for fall 1982) dramatically increased the number of women in the I&MSE graduate program. Several other women began graduate studies in the department at that time due to the advertisement of the program although they were not chosen as program participants. Most of this first class were still enrolled in the fall of 1983 and a second smaller class had also begun their studies at that time.

Due to the uncertainty of the future of the GRP, less effort went into advertisement for the 1986 class, hence fewer new women students enrolled. The increase in total enrollment in 1985 and 1986 is due largely to increased recruitment of foreign nationals and to the addition in 1986 of a Fellowship Program which was advertised nationally.

Although the total number of graduate women students in the department has decreased somewhat in the past couple of years, due to a decreased enrollment in the GRP, the overall effect of this program on the number of women graduates in the department is still quite dramatic. Undoubtedly the program helps provide a "critical mass" of women graduate students that encourages the enrollment of additional women and also provides adequate peer support for retention.

A secondary result of the advertising of the GRP was a simultaneous advertisement of the department's graduate program in general. Industrial Engineering is the smallest of the major engineering disciplines and most potential graduate students are not aware that, with the completion of a reasonable number of deficiency courses, a student can earn a master's degree in engineering without having earned an undergraduate engineering degree. Due to the advertisement of the program during the past seven years, the director has received inquiries from over 800 persons interested in career change. Many of these inquirers were not eligible for the GRP but were given information on the department's graduate program. Some have enrolled as graduate students and others are taking mathematics classes in preparation for the GRP.

In addition to an increase in enrollment, the GRP students have had an impact on the department's graduate program. Although students without undergraduate engineering degrees have always been a part of the graduate

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program, these students had never been very visible before this Reentry Program. The sheer size of the first group (28 students) and the fact that they were all women could not be ignored in a heavily male-dominated graduate student population. The reentry women often sat together in the front rows of their classes and thus were highly visible. These women had given up much to return to school and expected equal dedication from each professor. Usually a reentry student, a little older than the average student, quietly sits alone in his/her class with little interaction with other students. The GRP group, finding security and power in their numbers, gave immediate feed-back to professors on their classes. Any ill-conceived homework assignments or sloppy lectures were objected to en masse. As women, they also presented new view-points to topics of discussion in the classroom. In short, professors were challenged.

Although initially there was reluctance on the part of some faculty to support this reentry group, most of the faculty will now admit that the reentry women have been some of the best graduates ever produced by the department and their presence has had a positive influence on the department. Program participants have been sought by faculty for sponsored projects because, in addition to their technical knowledge gained through coursework, they are known to be reliable, dedicated, and good oral and written communicators. The Graduate Reentry Program has had a very positive impact on the I&MSE department at ASU.

SUMMARY

There is no quick or easy cure for several associated problems: a lack of women engineers, career dissatisfaction by many women college graduates, the demand by industry for more industrial engineers and advanced degree engineers, and the desire of a university engineering department to expand its graduate program. However, a solution which is a step in the right direction has been the establishment of a Graduate Reentry Degree Program for women in Industrial Engineering. Through the program and its advertisement, women are informed of the opportunities available in industrial engineering, engineering myths are laid to rest, and women are encouraged to pursue and to prepare for a career in industrial engineering. The successful Graduate Reentry Program has had a positive impact on increasing the number of women engineers, on the career satisfaction of its participants, on industry, and on the graduate program of its host department.

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WOMEN IN SCIENCE: NOW THAT WE'VE GOT THEM, LET'S NOT LOSE THEM!

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The underrepresentation of women in science-related areas has been the subject of intensive research in recent years. Berryman (1983) reported that in 1979-80 men, compared to women, received twice as many baccalaureate degrees in biological sciences, physical sciences, computer sciences, mathematics, and engineering, and three times more post-baccalaureate degrees in those areas. She determined that the pool of individuals destined to pursue science-related careers reaches its maximum size early in secondary school. After that time, all migration is out of the pool. The share of quantitative degrees thus reflects two factors: field choice and persistence. Intervention programs designed to develop girls' science skills and encourage their science interests are crucial for the field choice factor: they will increase the proportion of girls in the initial science pool. Programs aimed at decreasing attrition from this pool during a young woman's college years are also important because they affect the persistence factor. As the successes of intervention programs in elementary and secondary schools are realized, strategies to increase females' persistence in science-related fields will become even more crucial. This paper describes the development of one such program at a midwestern university, a career-planning seminar for college biology majors.

Development of the Intervention Program

The impetus for the development of the career-planning seminar was the realization that the attrition rate of college women from the biology major program at the university was greater than the rate for college men. Furthermore, achievement criteria such as college grade-point-average, were not determining factors in this attrition (Matyas, 1985). The young women who had survived initial selection into the science training pool had science achievement equal to that of their male peers, but nevertheless failed to persist in their science major. Apparently, factors unrelated to achievement were responsible for the high attrition rate of women. Comparison of non-achievement-related characteristics of persisters with dropouts revealed that dropouts were more willing to sacrifice their careers for the family responsibilities than were persisters, and they perceived significantly less peer support for their career goals than did persisters. The career-planning seminar built upon these findings. It was modeled after a similar course for women in engineering at the university. The attrition rate for women in that program was no greater than the rate for men, attesting to the success of the seminar and other programs for women engineering majors (Daniels and LeBold, 1982).

The biology career-planning seminar enrolled twenty women and two men in the Fall, 1985 semester. A variety of topics were covered during class sessions, which met for two hours a week during the first eight weeks of the semester. Several meetings were dedicated to career possibilities for biology majors: the director of the science counseling center provided information about resources available to students for career decision-making; a female biology professor described her career path and lifestyle as a university researcher; and a representative of a local pharmaceutical company discussed research and management careers in industry. Dual career couples attended one class session and addressed the family/career conflict issue. They not only described the joys of both their career and family roles, but also discussed the strategies they used to cope with the demands of both roles. A panel of professional and graduate school students compared notes on medical school, veterinary school, and graduate school and provided information about post-baccalaureate education to students. The director of the placement center at the university described services offered by the

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center to aid the job search. In addition, students developed their resumes and course instructors critiqued them. During the last half of the semester, class participants interviewed an individual in a career of interest to them and prepared a report of the interview.

The effects of the career-planning seminar were assessed both qualitatively and quantitatively. Students were required to keep a journal recording their responses to guest speakers and detailing insights they gained from each class session. Quantitative measures included a survey designed to measure aspects of career commitment. In addition, a course evaluation provided information about the usefulness of topics covered in the course. These surveys were completed at the end of the semester.

Effects of the Intervention Program

Course evaluations were very positive. Only one student indicated that he/she would not recommend the seminar to a friend, and over 80% felt the course had fulfilled their expectations. The class session with dual career couples was a favorite of almost all students and yielded comments such as the following in student journals:

> "(The dual career couples' comments were) not what I was brought up to expect from marriage; but I respect it, rather than dislike it."

> "(The) best thing about marriage and science I've heard and will always remember: make sure your partner is understanding of your job, career, and priorities."

Another favorite aspect of the seminar was the opportunity to talk with guest speakers and interviewees who had careers in the biological sciences:

> "(She) gave me a clearer idea of what is involved in research careers at the university."

In this instance, too, students indicated an interest in how the biologists integrated their careers with their personal lives:

> "(I was) surprised and happy to hear about her personal as well as professional life."

The development of job-search skills was greatly appreciated by students. All students found the resume-writing assignment valuable and many expressed surprise at the services offered by the placement center on campus. Comments in the journals included the following:

> "(The) most valuable thing I learned was to learn about the company you are interviewing with."

> ". . . throughout my college career I will reflect back to this course and put to use some of the commonsense tips."

Finally, several students noted the helpfulness of peer support developed during the seminar. One student stated:

> "Another aspect that was wonderful was to get together with other students to realize that you're not the only one who has no idea of what the career world is like and how to become part of it, and even to compare experiences in different classes and with different teachers and get advice on some courses from students that have already been there."

The responses of participating students on a survey which measured willingness to sacrifice career for family were compared with responses of similar students who had not participated in the seminar. Students who completed the career-planning seminar exhibited significantly less willingness to sacrifice their career goals for their families than did those who had not taken the course. In addition, course participants anticipated significantly fewer family/career conflicts than did those who did not complete the seminar. Apparently, tactics to resolve these conflicts were effectively presented during the course. These results should be interpreted cautiously, since students who elected to enroll in the career-planning seminar may have done so precisely because they had greater commitment to a biology career than did their peers who did not select the course. However, 90% of biology majors surveyed the year before the career-planning seminar was offered expressed interest in participating in such a seminar.

Conclusions

The persistence of women throughout the pipeline to scientific careers may be aided by providing career-planning seminars for college women in science-related disciplines. Interaction with students in the course described here revealed that college women in biology in the university had a great need for career counseling. Although several counseling centers and a placement center were available to all students on campus, the young women were largely ignorant of these resources. Students had little knowledge about the actual job tasks involved in the daily routine of specific careers. For example, one young women stated that she was rethinking her career decision after interviewing a laboratory technician. Although the individual she interviewed thoroughly enjoyed her job, the student realized that a technician's duties would quickly become tedious to her. After preparing their resumes, many students realized that they needed work experience as well as an academic degree. They began to search for summer jobs or volunteer work which would enable them to successfully pursue their desired careers. These are all examples of career-planning tactics which have eluded young women in the biology major program. This type of information is often passed on informally, but may be unavailable to young women because they are absent from the informal settings in which it is given (e.g., the locker room). The career-planning seminar counteracts this deficiency by expliciting imparting career-planning strategies.

The overwhelming interest of course participants in integrating their careers with their families indicates how important it is to provide young women with strategies to resolve inevitable family/career conflicts. The career-planning seminar effectively reduced anticipation of these conflicts by providing students with examples of women who enjoyed both a stimulating career and family life. The two young men in the class also enjoyed the dual career couples' session, indicating that family/career conflicts are increasingly problematic for men also. One student suggested that the course could be improved by "including more male speakers to get their side of the story." In fact, "getting males' side of the story" is essential, since families include both men and women, and conflicts betweeen careers and families cannot be satisfactorily resolved until both sexes join the discussion.

The career-planning seminar also developed a feeling of peer support among the students, a factor which was correlated with persistence in the biology major program at the university (Matyas, 1985). After the first class session, in which students introduced themselves and described their career goals, many of them noted their relief in discovering that other students had similar doubts and dreams. A warm camaraderie developed during the semester as older students advised younger students about class offerings and study aids.

Young women who pursue scientific college majors have survived the initial selection into the science training pool. By the college years, achievement factors have less importance than do affective and cultural variables for determining which women will remain in a science program and which ones will drop out. Career-planning seminars which provide a supportive environment while addressing issues such as career development and family/career conflicts, can remove some of the social barriers to women's persistence in scientific disciplines.

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ON THE EFFECTS OF STORIES, TOYS AND GAMES IN SCIENCE AND TECHNOLOGICAL EDUCATION FOR CHILDREN

------ Talk from the Beginning on
How I teach My Daughter

by Wang Hong

People's University of China

Introduction

My daughter was born on August 12, 1980. Since then I have done studies on children's education. As today in eighties, accompanying with the higher development of human civilization, the significance on early exploitation of intelligence and development of cognition have been clearly known by psychologists, educators and children's parents. It should be pointed out that science and technology education plays an important role in early education. Achievements of psychology and educational science indicate that the cognitive development is the result of interaction between a child and his (or her) environment, one's achievement is determined by his (or her) early experience to a great extent. The great parts of intelligence are exploited in preschool stage. A four years child may occupy50 per cent of intelligence which a seventeen years person possesses.

Population problem is one of the main problems in the world. The policy of birth control has been carried out in China. It is encouraged that a couple has had a only child either a boy or a girl. Then, a new problem may be introduced. There will be a lot of family has no son. It has forced people to pay more attention on girls' education which was neglected in the past. People all expect their children to be the great persons, but perhaps most of them are not quite clear how to teach their children. They are at a loss what to do. Sometimes, the results are just opposite to what one wished.

I have tried to teach my daughter in accordance with her aptitude and have won the initial success. I would like to summarize my own experience under the direction of educational principles and submit my paper to GASAT IV.

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On Stories

In order to promote children's development, many parents force their children to read, to write and to calculate in their early childhood. I considered that it is not the good method because it is more or less contrary to children's physiological and psychological needs. The results of a lot of scientific experiments indicate that the development of language is the initial intellectual development and expands quickly. By the age of three to four, the child has largely mastered the use of spoken language. In this stage, the function of the second signal system is rather week, the thinking mode is concrete, symbolic and emotional. Children cannot distinguish the differences between the various symbols of writing, such as the English letters b, d or p,q, until by the age of five. That is what I said, it is meaningless to teaching children writing words in early childhood.

Then, what is an adequate measure in language development stage ? The answer is quite simple. It is a story.

Most of interesting stories are chacterized by concrete language, vivid symbols and abundant contents. Children never get tired of hearing these stories and develop their abilities of imagine, attention and language expression gradually. Children's emotion and thought may usually arouse sympathy by stories. They understand the meaning and receive the truth what the stories implied. The general scientific principles in scientific imaginary stories are also easily received by children. In order to foster and train children with scientific temperament and scientific spirit in early age, you may tell them some scientists' and inventors' stories.

Stories may be told in various ways. You may tell stories dubbing background music or pictures. And you may tell stories by radio, tape or TV. But the simplest way is to tell stories by mothers' oral speaking.

Someone may consider that children do not understand the stories when they are too young to speak. I have refuted this view through the observation of my own daughter. When she was only several months, I usually told her a story of " The Shoes Which Can Cry " before sleeping. She heard me with smile and then went to sleep. Afterwards, when she could speak, I happened to tell this story once. It was a surpeise ! She can almost recite it sentence by sentence rhythmically. Now, she is good at stories telling and wor the prize again and again in story telling contests in school.

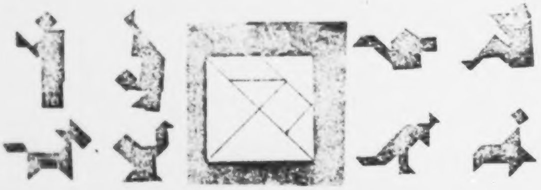
We should tell stories since the child was born. What a great person your child will be, his (or her) initial education started from mother's story telling.

On Toys

As the child growing up day by day, the successive development accompanying with language is action. Children like to play when they have already learned some simple action. Therefore, the effect of toys is the factor which can't be neglected in early education. If we say that mother is the first teacher to a child, then we may recognize that toys are the first teaching aids.

There are some points of view to be explained as following :

First of all, through the observations of children's expressions in playing games (including my daughter and her companions), I have learned that playing toys is same to doing works to children. They keep serious altitude and concentrate all their attention in toys. They do not enjoy only interests but wish to solve also some problems in playing. They want to satisfy their curiosity and thirst for knowledge which are aroused by toys. To take an example, seven-piece puzzle is one of the traditional Chinese toys which composed by seven pieces of platlets with different geometrical figures, five for triangles and one for each square and parallelogram. Children use them to form various pictures, such as a cock, a dog, a horse and etc. with great pleasure. They may master some simple geometry knowledge through puzzles, either.



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Secondly, the effects of different kinds of toys are varied although maybe all toys are beneficial to physical and mental development of children. The toys in big instrumental or machanic form may train the coordination of action and promote physical growth and development. Some small operative toys like blocks of construction may build up the movement of the minor muscular group and train technical skills, develop cognition and strengthen ability of self-control snd self-restraint. Some iminated toys which are closely related to real life may train practical skills and specific technique, such as, children learn cooking with iminated kitchen set which are same to real only small in size.

Thirdly, it can't be neglected that the effects of toys in fostering children's creative and inventional ability. While children play their toys, they may ask a lot of questions on structures, properties, functions and others about toys. Even they may destroy their toys in order to know some indistinct principles with curiosity. Once their problems are solved, they will do something more by themselves. It is rather good in learning. Moreover, it is a trial !

Some children will become famous scientists and great inventors, toys are their initial experimental materials.

On Games

Games are the largest psychological needs in higher intellectual development stage of children. They are relavant movement with children's growth, learning and development. In the other words, it is said that games are children's works. Therefore, games playing are the natural measure in children's learning.

Games have been usually organized in groups, since then children communicate with others in wider fields and begin to enjoy pleasure and happiness in social life. Children's characters are exposed evidently in group activities. All school teachers and all parents must pay some attention in observation of children's expressions in group activities.

At the beginning, my daughter studied counting and calculation in games, She iminated the numerals by material objects and called them with her imagine, such as, 1 is like a pencil standing straight in a row, 2 is like a duck vividly swimming in the lake, 3 is like the ear hearing the birds singing,.......

She started to play piano also in games. She imaged the tones accompanied with the stories she knew. She represented the lower tones as the terrible voice of a big grey wolf, the median as the soft voice of a mother rabbit, and the higher tones, the joyful voice of a baby rabbit. She considered that piano is a speaking toy. It is true, piano is not only a music instument but also a good and useful teaching aid in science teaching.

It is worthy to point out that children must be considered as the subjects in their self-development. While they play games they develop logical thinking internally and adjust their behaviors to fit with the social environment. They like to do what they are interested in but dislike to be control by someone else. At present, some kindergartens and many school teachers have already paid more attention on this theory and offered the favourable conditions to attract children in participation of games and scientific and technological activities. Teachers are instructors. They needn't take on what ought to be done by children.

Summary

To summarize above, it is quite clear that stories, toys and games play the significant role in children's early education especially in scientific and technological education. Our focus of attention does not pay only on talents with high I.Q. value but lay also upon the majority of children. Every child may develop all-round if we teach him (or her) in accordance with his (or her) apptitude. Let us do all we can to create a bright and splendid future for children.

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Women and Computers: An Isssue of Empowerment

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Early feelings about mathematics

Last Fall I attended a meeting sponsored by the Girls' Clubs of America where we were asked to remember how we felt about mathematics when we were between the ages of 9 and 14 years. Then we were asked to sit at a table that was labeled to match our feelings: "Math Whiz" if we had been very good at math and proud of it; "Bored Stiff" if that was the case; "Scared," and so on. And after we had chosen our table, one by one, all 50 of us stood up and revealed very significant things about ourselves, trying to understand how the person we were at 9 or 12 or 14 became the woman we were today. And math was the vehicle for that illumination.

It was both enlightening and very female--the ease with which we revealed ourselves to each other, especially our weaknesses. As people talked about themselves as children, all the old feelings of fear, inadequacy, and confusion about what it meant to be a female surfaced. I have seldom been in a meeting where such a degree of intimacy, common understanding, and sympathy was reached so quickly.

The group attending this meeting included people who work with girls, ages 6-18, in Girls' Clubs after school and during summers, as well as researchers, teachers, software developers, and scientists. We had met to discuss what might be the best ways to get these girls, who are mostly from poor and minority families, to become involved in math, science, and computer education.

What was so moving about the slices of life stories that we heard was the pain of our lives as girls, the lost opportunities, the seriousness of the consequences of bad advice. So many of us had, as girls and young women, been deflected from continuing in math by a simple remark from a teacher or counselor that suggested we weren't able to do it. Even those who had been clearly successful in math had so little ego strength that just one remark from someone in authority was enough to convince them they didn't belong in mathematics. For those who had persisted longer, the first difficult math class made them want to drop out because they could not bear to risk failure.

And yet each of us, as adult women, had become competent and successful, and we engage in risk-taking behavior fairly frequently. And each of us as chosen, as our work, to improve the life choices of young women so that they will not lose the opportunities as we had.

But what did we have to overcome to become risk-takers again, to regain confidence, and what must we do to help girls and young women believe in themselves? These were questions that emerged early on in the meeting, because what we had heard in our life stories, repeated over and over, are the same stories that are being played out in schools and homes across America today.

What we know about girls

- Many of our young women believe they are less able than their male peers in math, science, and computers, *even though* their grades are equal to, or better than, males of their age group.
- Many of our young women believe that, unless they achieve a perfect mark in math class, they shouldn't be there. Males can make much less desirable grades and not question the appropriateness of their being in the math class.
- Many young women perfer to play it safe than to risk failing at a task or in a class. Boys have much more support for taking chances, failing, and trying again.
- Many young women do as they are told, regardless of how bad the advice is, while males are much more comfortable questioning authority.

Research over the last decade has given us good information about the difficulties girls encounter as they grow to womanhood. The toys they are given, the expectations for their behavior, and the roles considered suitable for them combine to provide a much more impoverished and restricted environment than boys experience. We know, for example, that parents can be much more sex-stereotyped than teachers. They tend to think that if their boys are doing well in math it is because of their aptitude and if their girls are doing well it is because of their diligence.

More recent research on classroom learning gives us a good picture of what facilitates and inhibits girls' school learning. For example, in classes where girls learn (achieve) as well or better than boys, there is more cooperation and less competition, and girls have more positive attitudes toward math in those classes where cooperation is valued over competition.

What does this have to say to those of us concerned with the computer education of girls and women? How can we use the knowledge base of girls and math to avoid the mistakes of the past and ensure the involvement of greater numbers of females in technology in the future?

The gender gap in computer education

In the U.S., girls and young women use computers less than boys in their schools, enroll in fewer computer courses, drop out of computer courses at the college level more frequently than males, and advance much more slowly than their male colleagues in computer jobs.

Classroom Computer Learning magazine (April/May 1985) reported on the results of a number of U.S. surveys of computer use in and out of school. Summarized, the results portray a disturbingly familiar picture; if you substitute the word mathematics for computers, these findings could have been reported 10 years ago:

> *"Elementary school boys and girls generally like computers equally well.*
>
> *In the sixth grade (and usually before), there are no sex differences in self-confidence about, attitude toward, or perceived utility of computers.*
>
> *There is little difference in achievement among teenage girls and boys who take required computer courses.*
>
> *By high school, girls have less confidence than boys do in their ability to learn computer skills.*
>
> *After one course, 52 percent of girls are interested in taking more word processing or business applications courses; 59 percent of boys want more programming courses.*
>
> *Elective programming courses in high school have a two-to-one ratio of boys to girls.*
>
> *Among teen age girls, 7 percent use computers outside of class; 40 percent of boys do.*
>
> *Twenty-five pecent more boys than girls come home to a computer.*
>
> *There are three times more boys and than girls in summer computer camps."*
>
> (Beyers, 1984; Lockheed and Frakt, 1984; Cole and Hanuafin, 1983; Miura and Hess,1983.)

A number of theories have been set forth to explain these patterns, including:

- The computer came out of a male culture of electronic hobbyists who wrote software for themselves, which in turn attracted other men, thus perpetuating the culture;
- Parents more often encourage sons than daughters to learn about and use computers;
- Few role models of females using computers are seen by students;
- Girls are frequently hesitant to compete with boys for computer access in either the home or school.

Solutions to address these problems exist on many levels.

- Providing very early elementary school experiences with computers to develop computer interest, comfort, and confidence before school pressures intensify;
- Paying attention to the placement and location of the computer since girls tend to shy away from computer use associated with mathematics and gravitate toward those placed in a library or media room;
- Creating opportunities for cooperative computer learning, which can positively affect girls' self-esteem and give them a sense of control over a powerful machine;
- Offering teacher education programs that emphasize the teacher's role in discouraging and encouraging students in computer use.

Implications from the findings: What needs to be done

Many interested groups and individuals have generated ideas for ways in which teachers can encourage equitable computer use. I'd like to focus attention on three themes used in our programs: (1) How to motivate students to *want to learn* about computers; (2) How to increase the *amount of time* students spend using computers; and (3) How to improve the *quality of time* spent using computers.

Motivation. We encourage the teachers we work with to: discuss with students how computers are useful tools for everyone; conduct sessions for girls to meet women working in computer-using fields; provide counselors with information about computer avoidance and strategies for increasing female enrollments; integrate career information into the curriculum, with special emphasis on women and minorities; encourage female and minority teachers to become role models of computer users; encourage parents to seek out opportunities for their children to become computer users, at home, in camps, science centers, or other enrichment centers; and work with youth agencies such as Girl Scouts and Girls' Clubs to develop computer programs.

Amount of computer time. To ensure equitable access to computers, teachers cannot use a first-come, first-served schedule, or one that is controlled by students; they must create a schedule in which each student has an equal amount of time. Teachers must structure computer partner time so that turns are taken; chairs are arranged to ease sharing of key boards; and aggressive students are not paired with passive students. Same-sex pairing appears to work best for most ages. For homework, we require that teachers report on the numbers of males and females enrolled in the elective computer courses, so that they can see where the imbalances are occurring in their classes. We suggest that certain periods of out-of-class time be reserved for use of computers by girls.

Quality of time. To enable all students to have successful experiences in computing, we assist teachers in planning how to provide enough computer activities within a course to appeal to many different interests; to establish, from the outset, a non-threatening atmosphere for all students; to evaluate all software to be sure it is free of bias and to avoid software that stresses violent or too agressive competition; to encourage the use of word processing as an introduction to computer use and to use content from all subject areas in introductory classes; to use software to teach topics not easily taught otherwise, such as spatial visualization activities or simulations of scientific or sociological experiments; and, finally, to expect all students to perform the work or tasks needed for learning and to call on and praise all students equally.

These themes have emerged from the work I've been involved in for ten years--the

EQUALS programs. I am fortunate to work with a group of people, mostly but not all of whom are women, whose working style embodies the principles we believe in: cooperation, nurturance, the encouragement of risk taking, the fostering of support for each other's ideas and projects, and the importance of collective decisionmaking. This is sometimes not the most effective way to work but it meets our needs. The results are that we do agree about what is important to do, when to do it, and how we should go about accomplishing our goals for girls and young women. We have the freedom to develop our programs in our own way and on our own time schedule, which makes our programs a real reflection of who we are and what we think.

EQUALS

Ten years ago, we established the EQUALS program to help elementary and secondary teachers to increase the participation of female students in mathematics. Since 1977, 23,000 teachers in California and 36 other states have participated in EQUALS training and used EQUALS materials.

EQUALS teaches math as a collaborative rather than a competitive activity, since solving problems in a cooperative manner increases the confidence of those students who have previously experienced failure in mathematics, improves the chances of solving any given problem, and more closely parallels the way that adults function in the workworld where team work is a prerequisite for accomplishment. During EQUALS, teachers work together as problem solvers, so that they can provide this experience for their students. They too achieve success in the doing of mathematics, which, for many, is a new and tremendously exciting experience.

In EQUALS, teachers learn how to persuade their students that taking math now helps to ensure more options in the future. This is accomplished through career awareness activities and the introduction of role model panels of women working in math-based fields. Often for the first time, teachers learn how math and science are being used in a range of fields, and the interest generated by these role models is just as effective with students when role models visit their classrooms.

The impact of EQUALS over ten years has been demonstrated by increased enrollments of female students in elective mathematics and computer courses in EQUALS schools, improved student (both male and female) attitudes toward the study of mathematics, increased student interest in math-related occupations, improved student and teacher skills in problem solving, and enhanced professional development of teachers.

EQUALS sites are now established in ten states and five locations in California to offer the program to many thousands more teachers.

FAMILY MATH

In 1981, we developed a program called FAMILY MATH to help parents and children enjoy doing mathematics together. Many parents would like to help their children with mathematics but don't know how to begin. A FAMILY MATH course, taught by a teacher, parents, retired person, or community worker, in a school, church, community center, or home gives parents and children opportunities to develop problem-solving skills and to build an understanding of mathematics with "hands-on" materials.

By problem-solving skills, we mean ways in which people learn how to think about a problem using strategies such as looking for patterns, drawing a picture, working backwards, working with a partner, or eliminating possibilities. Having a supply of strategies enables the learner to have a choice of ways to start looking at a problem, relieving the frustration of not knowing how or where to begin. The more strategies you have, the more confident you become, the more willing you are to tacklen new problems, and the better problem solver you become.

By "hands-on" materials, we mean concrete objects--like beans, pennies, toothpicks--that are used to help children understand what numbers and space mean. Traditionally, these materials are used mostly in the early elementary years, and paper-and-pencil mathematics become the rule after second or third grade. This is unfortunate, since much of mathematics can best be explained and understood using the tools of manipulative materials and models; and, in fact, many research and applied mathematicians do just that.

Parents in the FAMILY MATH classes are given overviews of the mathematics topics at their children's grade levels and explanations of how these topics relate to each other. The curriculum begins to make sense simply by knowing how one concepts builds the base for the next.

Based on many of the same principles as EQUALS, FAMILY MATH courses are usually taught by grade levels (K-2, 3-4, etc.) with classes meeting for about two hours, from four to six weeks. Topics included in most courses are arithmetic, geometry, probability and statistics, measurement, estimation, and logical thinking--concepts that should be covered throughout the the K-8 curriculum.

Two-day leadership workshops, now offered throughout the country, enable people to prepare to teach a FAMILY MATH course. Over the last six years, nearly 15,000 families have participated in FAMILY MATH classes and several thousand parents and teachers have taken the leadership workshops. The program is now being used in schools, churches, and community organizations throughout the U.S. and Australia. Publication of the FAMILY MATH book and production of the film have brought the information to people all over the world. FAMILY MATH affirms the positive role that parents can take in their children's math learning and it demonstrates that math can be great fun for people of all ages an abilities.

EQUALS in Computer Technology

In 1983, Kay Gilliland, who had long been concerned about the inequity in computer use between males and females, and minority and majority students, developed the EQUALS in Computer Technology program, a 30-hour inservice program for teachers, counselors, and administrators who work with students in grades K-12, as a spinoff of EQUALS.

She designed the course to increase educators' awareness of the importance of equity of access and experience in computer education. The program provides on-line and off-line activities to encourage girls' and underrepresented minorities' involvement in computer courses; develops thinking skills in the areas most necessary for technical work; and provides experiences for participants to master the new technology.

Educators who attend this program have opportunities to investigate new software and to develop skill in choosing programs for school use; they increase their awareness of career options and develop strategies for increasing students' interest in the technical fields; and they acquire strategies to encourage equitable computer use by female and minority students.

The overall structure of the EQUALS curriculum is to stress the understanding of a few key concepts, using both online and offline activities. In particular, we stress comfort with the computer, cooperative problem solving, predicting outcomes, spatial visualization, the breaking of large problems into parts (using Logo procedures, for example), and the process of diagnosis or debugging.

After attending the inservice, participants use the activities and materials in their own classrooms and conduct presentations in their districts for parents and teachers, school board members, and community groups. The impact of the program is measured through pre- and post-surveys, daily rating sheets, and enrollment data. The post-survey data since 1983 have identified significant changes in participants' perceptions of their abilities to handle equity issues, offline activities, software decisions, and technology-related career information.

There has also been professional growth by teachers, evidenced by their presentations of EQUALS in Computer Technology materials at faculty meetings, conferences, and school board meetings, as well as their active participation in developing master plans for computer education in their schools. Finally, there has been an increase in female enrollment in computer classes in EQUALS schools from 20% in 1979 to 47% in 1984, the second year of the program. This is greater than the increase evidenced in California schools generally over the same time period.

While we are pleased with these results, we are by no means confident that the equity problem is being taken care of. We know that most teachers do not feel that equity is a serious problem in computer use, even though the data demonstrate that it is. Thus, we must redouble our efforts to assist teachers in observing, understanding, and eliminating gender-biased practices in computer education.

What U.S. women need to do

The discussion so far has been limited to increasing access and equity for female elementary and secondary students and teachers. The EQUALS in Computer Technology program does not address the needs of college women, women re-entering the workforce, or young women out of school or out of the workforce. All of these populations are in need of attention to encourage their computer participation. Some excellent programs have begun, but the majority of women in the U.S. do not have access to them. Further, the major computer organizations have not established equity as a priority and, although many women have become computer leaders, these organizations remain male-dominated and male-oriented. To make major breakthroughs in the population's awareness of the importance of this issue, it will be necessary for women's organizations, agencies that are committed to women's equality, and individual women to keep the media informed, to reach out into the community to publicize the issues and the resources available to resolve the problems, and to commit their time and energy to working on this.

It is also important for U.S. women to understand the implications of technological development on other populations. The policy and decisions that are made about the direction and the priorities of new technologies have been made by men in Western industrialized countries, with virtually no input from the women in these countries nor the people for whom the technology is intended. Too often, we limit our vision to what is good for the specific (and small) number of women we are serving, forgetting that the new research and development efforts in science and technology are often tested on third world women (particularly in the health fields), or women from underdeveloped areas in our own country. As women, we have been singularly unsuccessful in determining the development and directions of the new technology. We cannot afford to remain outsiders to these decisions any longer.

What we can do together: The international community of women

Those of us fortunate enough to attend the United Nations' "Decade for Women" conference in Nairobi in July 1985 were able to expand our understanding of the role of women throughout the world. We were able to see and hear first hand what other women's lives are like, what they need, and what they want. We were able to understand each other, to find a collective vision, to talk about how to work together, to decide what we want to accomplish, and to find ways to work together on issues we've determined are the important ones.

We have an opportunity at this conference to experience some of the power that we felt in Nairobi. We can lay the beginning of an international effort to determine the course of technological development in our spheres and to work together to accomplish that.

We can begin with the exchange of ideas, materials, and research that will occur throughout this conference. But we should be sure that we don't limit ourselves to that. We should be setting individual and collective agendas by articulating what is important to each of us as women concerned with technology, as citizens of our own countries, and as members of the international community of women.

For example, for myself, I care about and work towards the goal of computer empowerment of girls and women by directing my energy and resources toward teachers. As a U.S. citizen, I try to understand new technological developments and the impacts these might have on the poor, the unemployed, ethnic minorities, and women. But as a member of the international community of women, I am not constrained by notions of what is or is not possible in my job or my country. I have, at least for these few days, the freedom to explore what common experiences we share, what important differences there are between us, and how we might forge a collective vision of what we want together. This kind of thinking and talking will not only inspire us, it can also move us to new actions that will, in turn, create new results.

I look forward to developing this vision here and to leaving this conference with new friends, new ideas, and new plans to put into action.

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A Course in BASIC TECHNOLOGY FOR TEACHERS IN PRIMARY AND SECONDARY EDUCATION. 1986.

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The following article is a summary of the reports from the schools which participated in the Course in Basic Technology for Teachers in Primary and Secondary Education. Quotations and examples from these reports have extensively been included.

The article will form part of a report on the total experiment.

The course was established in co-operation between LEGO and RACU (The Regional Centre for Analyses of Youth Education in the County of Vejle - Det regionale analysecenter for ungdomsuddannelser i Vejle amt).

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"Girls as well as boys in the two classes reached the impression that a technological development has always had some drastic consequences, good and bad. In both classes mostly the boys were inclined to speak their minds. I am still more and more convinced that girls are less eager to appear on stage in the class. On the other hand I noticed a rather considerable interest especially from the girls in the 9th grade*) when we discussed the consequences for human beings and environment. But that just confirms our prejudices.

Either it is easiest to discover what is expected or my pupils were extremely "ordinary", the girls were best to put up with given tasks and took their time to study how it really functioned, whereas some of the boys needed very much to go completely their own ways.

My conclusion must be that the girls as a group devoted themselves to the tasks and tried to solve the technical problems with an enormous energy, and that their tenacity and meticulousness mostly lead to a good and solid result. The boys, too, in general threw themselves into their work, but their impatience often spoiled the quality of the product.

There can be no doubt that working together with other girls and feeling my huge interest in their solutions meant a lot for the girls' development. They often expressed great satisfaction when they succeeded in making a thing function. They saw that technology can be learned and that it was rather funny."

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*) In Denmark the children start in nursery school class at the age of 5-6, then at 6 or 7 they proceed to 1st grade and finish the compulsory schooling in 10th grade.

So it is said by one of the teachers who participated in the formative work called "Course in Basic Technology for Teachers in Primary and Secondary Education". We have chosen to quote her because one of the negative expectations to the project was that trying to make teenage girls interested in "playing with LEGO" was foredoomed to failure. However, this course carried out in 9th grade shows that if the teacher knows how to approach the matter with an understanding and respect of girls and their values, the girls are likely to experience both curiosity about technical problems and pleasure in technical ability.

Before we tell further about the experiences which the participating teachers and we, the responsibles for the project, have had, we will give a short description of the course and its background.

The two of us, a former equal opportunity counsellor at the public employment agency in the County of Vejle and an educational adviser in the County of Vejle, got the opportunity to start a project about girls and information technology in 1984 in Vejle. At that time, results from the classroom research were little widespread, and furthermore from the school year 1984-1985 data processing was to be offered in the 8th grade. We wanted to make a real effort in order to support the female teachers who were interested in working with girls' problems and who wanted to influence the development for the integration of EDP in the education system.

This made us start the Network Group of Female Teachers from primary and secondary education and youth education*) in total about 20 teachers. The seminars and meetings in our group and the information spread out through the group have resulted in several activities at the schools involved.

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*) About the Network Group cf. Benthe Stig: "A Network of Female Teachers". Concerning girls and dataprocessing cf. Janni Nielsen and Lisbet Roepstorff: "Girls and Computers - Delight or Necesssity?". Both articles in Contributions to the Third GASAT Conference, Chelsea College, University of London.

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In the autumn of 1985 we had for the first time an arrangement where we asked the members of the Network Group each to bring along a colleague. We succeeded in getting EQUALS from Lawrence Hall of Science, the University of California, Berkeley, to Denmark in order to demonstrate how to teach data processing in a way that arouses and maintains the girls' interest.

One day was reserved for the Network Group. This arrangement had many advantages. It gave the Network teachers new knowledge and inspiration and the joint experience made the colleagues positive co-operation partners. Moreover, the arrangement gave status to the Network Group among educationists.

The EQUALS-seminar became the direct cause of our contacting LEGO. We had learned that LEGO was working at a series of teaching materials, LEGO Technic. Some parts of it had already been introduced abroad, but was not very known in Denmark. At our request LEGO invited the Network Group to a meeting where a Swedish teacher, Harriet Axelsson, told the participants about her experiences in instituting technical/scientific experiments in education and introduced the LEGO Technic. At the end of the meeting a number of Network teachers said that they were interested in participating in an educational course about basic technology.

Immediately hereafter we planned a course in basic technology for teachers in primary and secondary education according to following principles:

- the course was to take the Network Group as its starting point
- the idea of involving colleages was to be developed so that the participants formed groups of 2-4 co-operating teachers from each participating school
- the course was to aim at the use of technical experiments from the nursery school class to the 10th school year with special attention to girls
- the technical experiments were to be part of the subjects and only include LEGO as one of several elements
- the participating teachers were to elaborate, implement and report the educational course.

HOW DID THE TEACHERS HANDLE THE WORK?

The topic was - except for one case where the pupils wanted to proceed with the topic "Work" from the year before - decided by the teacher. The frames for the pupils' liberty of action within the topic is very different.

In some of the youngest classes it has not really been a topic but LEGO Technic has been one among other offers to the pupils.

The technical topics have been integrated with much diversity. In some cases they became an element of an already planned course and in other cases LEGO Technic was the only technology, whereas other teachers have had very variated courses with the use of many different materials and with an historical and a social aspect of the importance of the development of technology. There have been many different courses cutting across the dividing lines between subjects.

In general, the guidance for the teacher has not been followed, but has been an inspiration at an early stage in the planning.

The grouping has been rather variated from "one girl and one boy, as usual" or self-elected groups to deliberate division into groups of only girls or only boys and mixed groups respectively. One school wanted all pupils to try to work in both 'pure' and mixed groups. Elsewhere the mixed groups were with girls estimated to be sufficiently 'strong' to assert themselves.

The relations girls/boys and girls/technology have generally been given high priority by the teachers who participated in the Network Group's previous work whereas some of the other schools have given limited attention to the matter.

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Grade	Subject	Pupils	Topic	LEGO models
nursery school class	all	5 girls 6 boys	no topic	experimenting exploiting
2nd	Danish	11 girls 10 boys	energy wind, sun, water	water and wind mills the material also used without actual topic
3rd	general studies	9 girls 9 boys	weather and wind	wind mills (several constructions in other materials)
3rd	Danish general studies creative art	5 girls 10 boys	work (visits at enterprises), descriptions etc	wheel chair, circular saw, drilling machine, tractor excavator, lift, jack
4th	Danish mathematics creative art music general studies	9 girls 11 boys	coral island (forced landing and survival on a desert island)	helicopter, system of transport for drinking water across the island
4th	Danish general studies	11 girls 12 boys	means of transport	Bicycles, cars, trains planes and ships
5th	Danish general studies	10 girls 8 boys	data processing at the intermediate stage	
6th	mathematics Danish general studies English	7 girls 10 boys	mass media	construction after LEGO cards

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Grade	Subject	Pupils	Topic	LEGO models
6th	Danish general studies	9 girls 15 boys	the local community (farm dairy co-op)	agricultural machinery lawn mower dairy machinery cash register
9th	mathematics civics	5 girls 11 boys	development in technology - friend or enemy	belt transmission chain transmission technical principles/notions
9th	Danish civics	-	agriculture	Elevator, assembly line mucking installation, tractor with manure spreader and beet digger
9th + 10th	all	13 girls 18 boys	sex roles problems	electric food mixer drilling machines

EXPERIENCES FROM TEACHING

The teacher has a very central position in experiments with other practices of teaching and their implementation. Here both the teacher's own interest in the topic and his or her planning of the course are decisive for the active involvement of the pupils in the course.

And from the experiences of the different courses it did indeed turn out that the teacher's part in planning and implementation of especially untraditional courses is very important.

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As expected the reports we received show that the sex-related differences in attitudes and motivation as regards work with technical material are not so pronounced in the youngest classes, but they are intensified and cemented during the school years and become more firm notions of what boys and girls can and ought to do. However, the material indicates also that it seems to be possible to shake deep-seated attitudes by creating a new practice of teaching which stimulates girls' curiosity about technology and which takes sex-related differences of working methods into account.

Experiences with the LEGO material

In general it seems that there is no important difference in girls' and boys' interest in working with LEGO. The girls' uncertainty on the material makes them, however, at first more tied to guidances and given directions.

"Please help us, we are only girls."

Both sexes are motivated in order to try the new material if for no other reason:

"The children are so used to work with books, that it is a relief when times to times other possibilites are offered."

and

- "The advantage of the material is that it is possible to connect play and solutions of problems."
- But this connection is not unambiguous because:
- "Some pupils had to get used to the fact that LEGO also had a learning function beside the play. Some of the most immature pupils never got used to this."

But

"The LEGO material demands a teacher who finds it interesting to work with LEGO."

In several reports and from interviews with teachers there are examples where literate weak pupils have been fortified through a working process stressing the preparation of concrete objects and not the production of words. The fact that these pupils have been able to construct and make a demonstration without words being a central factor has strengthened them and given them self-reliance.

"Weak pupils gained more self-confidence because the other pupils realized that they were able to make something important."

The material is also suitable for an approach to subjects where the pupils' experience is limited. It is possible to touch the objects, see and feel how they function together, take them to pieces and assemble them again. This is important in particular for the girls who might for the first time touch gear wheels, pulleys etc. and watch their functions. Today these areas are "blind spots" to many girls. LEGO gives the cildren the opportunity to explore fields which would not be possible in the ordinary education. But both among girls and boys there are pupils who get tired long before the others. This also applied to pupils who were not used to have problems with the given tasks.

Furthermore, many participants found it releasing to work with concrete and clear tasks where solutions required a real co-operation between the pupils. The teacher's part was here changed into that of an adviser, and the function of LEGO was to concretize connections so that they became easy to grasp.

Some teachers have been rather fixed on the LEGO material and have not included other materials. Others have used LEGO together with a lot of other objects. In 2nd grade they made paper darts out of different kinds of paper and measured the time and length of flight. They have made and tested water wheel and wind mill, windsock and parachute. They have placed plants in light and darkness, made and sailed with boats in

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cardboard and so on. They had "aha-experiences", were able to understand connections and possible applications and to make proposals of improvement.

Experiences concerning the pupils

To a great extent the experiences correspond to what we already know from the classroom research and from the research on girls and physics, girls and technology, but of course with a slight difference of meaning.

Already on the second day of the course it was a pleasure to note as confirmed in the reports that also the girls in the oldest grades had had good experiences and shown both interest, endurance and capacity to find solutions in connection with the technical experiments.

But the older the girls are, the more important it is that the technology is a part of a whole which they consider as meaningful.

In general the groups of only girls functioned well. This also applies for the mixed groups in classes with a good social background. But according to several reports there were mixed groups where the boys took over the lead, while the girls made proposals, undertook the tasks of writing and decoration, or they felt kept outside. One of the differences observed is that the girls talk with each other about the process whereas the boys are much more experimenting as to the manufactured products.

One group of girls in 4th grade, who worked very consciously with the technical/scientific topics and with a departure from the traditional sex roles, appealed to the teacher: "Please help us, we don't have any boys in our group."

In the reports it is often observed that the boys are beforehand used to play with technical and mechanical toys. This gives them the advantage of knowing the material which makes them more assured in the work. However, the boys' impatience often spoils the quality of the product.

Often the girls can be helped to start or to surmount their difficulties by means of the activity cards. A teacher in the nursery school class says:

"At last I succeeded in tempting some girls to play with objects. They had many difficulties in starting so we agreed to try to make a sewing machine (card 3) And fortunately what I wanted to happen did happen: The girls grew curious, they wondered and they had a magnetic action to the other children. There were plenty of work and tests with the sewing machine for many days, we could not stop wondering what would happen if we twisted the rubberband or if we shifted the size of wheel."

"It takes a longer time for the girls, but they end up with a solution and thereby they have made several important technical reflections during this work." (Observations from 4th grade).

In a 5th grade where all the boys, but only 2 out of 10 girls, had experience with technical or mechanical toys, the problem was solved by using the technical auxiliary machines from the home with which both boys and girls were familiar. Their principles were then transferred to other machines by means of LEGO.

A 4th grade being shipwrecked on a coral island was to solve problems like for instance drinking water which unfortunately was on the uninhabitable side of the island. The mixed group and the group of boys made solutions based on the use of an engine and a chain drive across the mountain ridge, whereas the group of girls chose a solution where they used human power only and transported a person to and fro to fetch the water. They used a system similar to that of a breeches buoy. They helped each other and kept on stubbornly trying to make it function. In the group of boys some of them did not have the required endurance in the group work. Suddenly they retired, made cars or nothing at all and thereby let the others handle the task.

Especially for the older pupils it was pointed out:

"That the groups with only girls functioned well, while the groups with only boys had some difficulties in co-operating. E.g. some of the groups with only boys could hardly function because they did not co-operate, some solved this problem by taking turns to build. A real solution of problems in community was out of the question."

"The mixed groups functioned, especially because the girls were satisfied to be those who tidied up, assisted and watched. "Anyway, he knows more about it" was the common remark. When pressed, the girls who made their first experiences in a mixed group would like to participate more which they did later when they worked in group with only girls."

Experiences with the teachers

The teachers have entered the tasks with a huge imagination and an enormous engagement. But backgrounds, possibilities and preferences have been very different. One extremity was a teacher who had to take over the project after a departed colleague without previous participation in neither the Network Group nor course days.

The other extremity is a school with considerable interest for the project where they granted hour reduction and additionnal teachers. Some places the participating teachers have beforehand had a topic which was fitted into the teaching of technology. Some teachers - and classes - had worked with LEGO Technic before. Others had to be guided in order to get started with LEGO but it was to great benefit for both teachers and pupils.

One teacher - who has participated since the start of the Network Group and who works very consciously with girls' problems - could not get interested in the LEGO material and this is reflected in the course which she and her colleagues made. Another female teacher had entered the course without knowing of the Network Group or participating in the course days. She was clearly anxious about the use of the unknown material and signaled evidently to her pupils that this was not for girls.

In the Network Group we have often discussed experiment with groups of only girls. Even though many teachers have experienced some advantages, they have, however, obviously some difficulties in consequently making sex-divided groups, or they let the pupils choose themselves, for instance according to their interest in the topics. Other teachers who have not participated in such discussions have made mixed groups as usual. As an example one of them states as part of the output of the project that he has become more conscious about the problems girls-boys. As a matter of fact the involvement of others than the "old" Network teachers has yielded some good feelings of some teachers having new impulses and new engagement.

Several teachers reflect on their roles in these courses:

"My role as a teacher was by means of LEGO and other materials changed a little. If the teacher wants to make the teaching more like the work in a workshop, his or her role will be like that of an adviser."

"As teachers we have been very pleased to be in position to call in another teacher in some lessons, because this gave us the opportunity to discuss much with the individual groups about the solutions in relation to the various problems which turned up in the course. In the course we have had many good discussions with both the individual pupil and the class as a whole."

"Our roles as teachers in this period have been more as advisers and practical planners than teachers in a proper sense. The pupils have made experiments, experiences and acquired knowledge about the functions of technology."

However, visits of observation have also shown that it can be difficult for a teacher both to get out of the role as teacher (to give the solution, the result, when the patience to solve problems runs out) and to get rid of the perhaps unconscious attitudes to what boys and girls can and must. It is a long process both to achieve consciousness and attentiveness and capability to translate it into action.

The group of teachers had at their disposal the teacher's guidance to the LEGO material but these were only used to a small extent. The courses give evidence of very inventive teachers and there has been no request put forward in order to have "ready to cook" recipes for the total course. The teachers tend more to want a series of ideas and inspirations.

THE TEACHERS' CONSIDERATIONS ON AND ATTEMPTS TO BREAK DOWN THE BARRIERS OF TRADITIONS

All the teachers have considered and gained experiences with the problems of girls and boys in relation to technology. In interviews more teachers have delivered their considerations and experiences. These indicate that the teachers' willingness to see the problem boys/girls and to use this in the planning of the teaching is necessary if more girls are to be involved in an active way. For instance groups of only girls force the girls not to let the boys dominate them.

Many have stated that it is a condition for the girls' active involvement that the girls' curiosity is roused and that they have plenty of time to become acquainted with the material. Others stress the importance of consciously setting the girls in motion -

"They do not spontaneously choose to make a work which after all is not for them."

The girls slip too easily into the role as spectator or are assigned the duties of writing and tidying up. But on the other hand -

"It looks as if something is happening to the girls when they are pushed, little by little they start to think technically."

A teacher from the nursery school class says:

"To begin with, the girls had to be pushed, they do not choose LEGO Technic by themselves. First I did not hand out the construction guidances. They were hidden away for a long time. Many did not dare to start. But when they saw the construction guidance they began to build a sewing machine.

My experiences from this period tell me that if only it is something girlish, they get on with it. One day they started to work on something

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they thought was a sewing machine when suddenly a boy came by and said: "This card is for a drilling machine", but at that time it did not matter to the girls. They were started, they had constructed something and it functioned."

Several times it was pointed out that at the beginning the guidance material supports the pupils who are not familiar with the material (as a rule the girls). But on the other hand and on a longer view the guidance is a drag on the pupils constructive abilities because it binds their imagination, and this applies for both the boys and the girls.

The teachers' expectations from the girls' abilities and wishes to work with technical problems are important in connection with the pupils' motivation for technical topics.

The female teachers who find it interesting to work with technical problems are good identification models for the girls. In the classes where there are female teachers and they show that technology is a naturalness to them, there are also the girls who make a lot of experiments, even in the 9th grade. If the female teacher has the opposite behaviour, the girls also have less interest, even down in the 3rd grade.

PROBLEMS

The greatest problem for us who planned the course has been the lack of time to follow the courses at the individual schools. This was very alleviated by the third among us who worked with the project as a part of her special subject and contributed by means of her observations.

At several schools the problem has been that the teachers' timetables were changed or that the teachers left the schools so that the course had to be taken up in another class than planned at first or perhaps by one teacher instead of a co-operation between more teachers.

NOW WHAT TO DO

- ABOUT THE DIFFUSION OF EXPERIENCES FROM THE PROJECT?
- ABOUT THE NETWORK GROUP?
- ABOUT THE LEGO CO-OPERATION?

The answers will have to wait a little and, we hope, will appear from a more detailed report which we intend to make as part of the diffusion of experiences.

So, as it is written in the weekly magazines:

"To be continued".

(AD-30.12.1986/HVF)

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Beginning Science Equitably

Barbara Sprung

Educational Equity Concepts, Inc.

In November, 1985, at the annual meeting of the National Association for the Education of Young Children, Shirley Malcom, Director of the Office of Opportunities in Science, American Association for the Advancement of Science presented a paper titled "Equity in Science, Mathematics and Technology Education: Early Childhood is the Place to Start."[1] The paper was delivered at a one-day forum called **Redefining Equity Issues for Early childhood in the 1980s and Beyond** conducted by Educational Equity Concepts. Dr. Malcom began her talk by saying:

> I teach young children although I am not an early childhood educator. I study young children although I am not a researcher in child development. I am an advocate for early childhood education only as an avocation.

She then went on to cite the well-known, but none-the-less appalling, statistics on the lack of participation in the quantitative sciences by women, minorities, and disabled people, and to stress the importance of intervening early enough in the educational process to ensure that all children regardless of sex, race, disability or socio-economic status have the opportunity to develop positive attitudes and skills that will allow them to both aspire to and qualify for careers in the fields of science and technology.

To paraphrase Shirley Malcom's words, I am not a scientist, but I have helped scores of young children engage in the process of discovery that is science. I do not engage in formal research but I have made the study of early childhood education my life's work. I am an advocate of early science because I believe that the antecedents of all later learning should be present in the early childhood curriculum in age-appropriate ways.

I have been an early childhood educator for a very long time. I am a practitioner and an activist. Since the early 1970s, I have been developing curriculum, teacher and parent education programs, films, and hands-on classroom materials and toys. All of my work has focused on creating equity for all children, beginning at the preschool level. Looking at early childhood from the perspective of equity has been an expansive process for me.

Initially my work was to develop curriculum and materials that were nonsexist and multicultural. Then in the mid 1970s, as the mainstreaming effort in Head Start and the public schools was getting underway, I realized that an equity approach also had to be inclusive of children and adults with disabilities. In 1982, I co-founded Educational Equity Concepts with Merle Froschl specifically to create programs and materials that encompassed a comprehensive view of equity. Our equity work spans the educational continuum from preschool through adult women. In undertaking new projects we try to develop programs in areas where there are voids. Early childhood science certainly is such an area. I think one would be hard pressed to argue that science and technology have a strong place in the early childhood curriculum, and when one looks at it from the perspective of equity--who is participating in activities that develop science-related skills--the void indeed becomes very wide and deep.

In 1983-84 I had the opportunity to serve as project director of **Beginning Math and Science Equitably** a program funded by the U.S. Education

Department, Women's Educational Equity Act to develop an early childhood curriculum that would promote the development of visual-spatial, problem-solving and creative thinking skills. I think that by describing the work of **Beginning Science Equitably**, and the curriculum it produced, What Will Happen If...Young Children and the Scientific Method I can best share with you the effectiveness of an equity focus on curriculum development.[2] I'll be speaking about the project from three aspects: **research, curriculum development, and staff development**.

Research

Several different areas of research informed the development of **Beginning Math and Science Equitably**. One area already has been mentioned, the statistics that point to the numbers of women, minorities, and people with disabilities who never gain the motivation or skills needed to qualify them for careers in science. Susan Berryman, Shirley Malcom, Lucy Sells, Jane Butler Kahle, and many others have documented this lack of participation, citing low teacher expectations, low student self-esteem, biased career guidance, low parental aspirations, and other factors of poverty.[3] Students are lost in the educational pipeline long before they reach high school or college. The result is that the sciences, especially the quantitative sciences, are still largely dominated by white males. This situation has obvious economic ramifications, but it also means that large segments of the population are not knowledgeable enough to make intelligent decisions regarding the environmental, energy, health, and defense future of our country.

Several areas of early childhood research also informed the project. One was the longitudinal study reported in the High Scope Foundation monograph, Changed Lives, attesting to the importance of a quality preschool

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experience, including opportunities for independence and decision-making, on future development.[4] The High Scope study has validated what early childhood educators have long known--that a quality preschool experience is the best beginning a child can have to the process of education.

Another area of research looked at gender-defined socialization and play patterns that children typically develop in the home during the first three years of life, which result in boys and girls entering preschool with very different learning attributes already in place. Selma Greenberg, Professor of Education at Hofstra University and a noted equity specialist, has organized this research into eight sets of learning attributes commonly observed in young children. Girls enter preschool with verbal, fine motor, repetitive, nurturing, one-to-one, role rehearsal, adult modeling, and impulse control experiences. Boys enter with spatial, gross motor, inventive, managing, group, career and life option, direct instruction, and self-worth experiences. Dr. Greenberg goes on to state that once children enter preschool, they tend to self-select activities they already do well or can master with certainty. Unless the early childhood teacher is aware of the gender-based differences and the self-selection process and makes a conscious effort to see that each child develops a full range of skills, deficits in the unselected areas may begin to develop.[5]

Lisa Serbin, an early childhood researcher, also has looked at patterns of sex-differentiated play in preschool. In research focusing on the specific visual-spatial skills that one learns by playing with blocks and other three- dimensional toys. Dr.Serbin and her colleagues have found that "practice" can make a difference. First, they found that children of both sexes who played with male-preferred toys such as blocks, construction materials and transportation toys showed relatively higher visual-spatial abilities than children of both sexes who played with female-preferred toys. They then set up a study in which children were exposed to daily 15 minute sessions designed to build visual-spatial acuity through the use of three dimensional construction materials. After a five-week intervention, children who participated in the activities performed better on several visual-spatial tests than children in the control group. Also, those children who had had the least experience with construction toys benefited the most from the "practice".[6]

Curriculum Development

To create the **Beginning Math and Science Equitably** curriculum, a group of experts came together in January of 1984 for a two day meeting in New York City. Included were science specialists, equity specialists, teachers, researchers, curriculum developers, teacher educators, and school administrators. For two days people met in large and small groups to brainstorm ideas and to refine them into an overall curriculum design. This meeting generated the underlying premise of the project: **As we move toward the 21st century and a society based on technology, activities designed to develop math and science skills and an understanding of the role of technology are as essential to the early childhood curriculum as are activities to promote language development and prereading skills. If children are to gain an understanding of the world in which they live, attention must be paid to the scientific and technological aspects of that world from the beginning of the educational experience.**

From this premise grew a curriculum that is rooted in the physical sciences. The curriculum uses typical early childhood materials such as blocks, sand and water, and sensory materials in new ways. For example, blocks are used to construct ramps to experiment with the effect of inclined planes on speed and distance; children make their own sieves which they use in water and sand to experiment with the concept of flow; and they work with bottles filled with different liquids to explore concepts of solubility, density and viscosity. In addition, there are several activities that help children to explore technology in the context of the world around them. For example, they work with small machines such as a food grinder and they take trips in the community to find out how things work.

The activities are structured according to a simplified version of the scientific method: children hypothesize (guess), experiment, observe, conclude, and document their findings in simple ways. The activities, which are structured, are meant to supplement rather than replace the ongoing discovery process that happens in an ad hoc way in most early childhood classrooms. To ensure that everyone participates, the activities are "required." It is left up to the individual teacher to decide how to involve children who wouldn't self-select the activity on their own. During the pilot testing of the project, invariably those children who were reluctant to try the activities ended up enjoying them the most. Given the self-selection process, however, these children, if left to their own devices, would never have experienced the activity at all.

The curriculum was pilot tested with three, four and five-year-old children in the Lawrence, New York School District. The early childhood program in Lawrence was centered in School Number Four, which drew children from a five town area. The socioeconomic level of the children ranged from families receiving aid to dependent children to upper middle class. The racial and ethnic mix was equally diverse, encompassing Black, Hispanic, white ethnic, Indian, and Asian-American children. The educational program

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in Lawrence was top quality, with many special program enhancements and the teaching staff was of extremely high caliber.

Staff Development

The final area I want to discuss regarding **Beginning Math and Science Equitably** is staff development. This area needs to be examined from several aspects. First there is the issue of self-selection. Most early childhood teachers are trained to create a rich learning environment for children comprised of area for dramatic play, art, reading, manipulatives, block building, and gross motor play, and then to let children self-select from that environment those activities that they like. We know from the research that this practice can lead to deficit areas of development for children.

The early childhood classroom, however, does have areas of curriculum that are required. Activities that promote verbal skills, listening skills, social skills, and fine motor development skills that foster the development of later proficiency in reading and writing are stressed on a daily basis. Returning to Selma Greenberg's initial learning attributes, it becomes clear that the areas of emphasis in the typical curriculum are those that remediate boy's areas of weakness. Gross motor activities, such as outdoor play and visual-spatial activities such as block-building, usually fall into the realm of free play and are not required on a daily basis. These, of course, are the areas in which girls have weaknesses, and they are neither recognized nor consciously remediated. Intensive preservice and inservice training is needed to help teachers become aware of these differences.

Another issue that must be addressed is teachers' discomfort with science and technology. The overwhelming majority of early childhood teachers are female, and they have little or no background in science. The few who do include science in the curriculum concentrate on plant and animal care or on nature studies. While these topics are important and appropriate, physics and technology activities are virtually nonexistent, owing to teachers unfamiliarity and discomfort with these areas.

Given the inequities in science education, it is imperative to prepare early childhood teachers, through consciousness and practical training, for the important role they must undertake. As the first and strongest influence on young children outside of the family, they can begin to create equity by ensuring that all children acquire crucial visual-spatial, problem-solving, and creative thinking skills.

Notes

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THE COMMITTEE FOR WOMEN AND SCIENCE IN THE NETHERLANDS

JOKE TROMP

VROUWEN EN NATUURWETENSCHAPPEN

Introduction

As the chairman and a representative of the committee "Women and Science" from the Netherlands, I would like to tell you something about the problems and solutions in reaching our goals. The committee's aim is increasing the participation of girls and women in science education. We mainly, but not exclusively, focus our attention to the secondary education level.

This committee was founded in 1982 bearing the name "Meisjes en Natuurkunde" (girls and physics). At the 1983 GASAT conference Cathalijn Drukker' made mention of this. Since then the attention has been extended further than just physics, and now chemistry and biology have been added, so that the name "Vrouwen en Natuurwetenschappen" (Women and Science) seems a more appropriate term. We are closely connected with the Dutch Association for Science Teachers (NVON).

At the moment our group consists of about 30 women and men: teachers, teacher educators, curriculum developers, MENT co-workers, educational researchers, policy makers and so on, who are concerned about the current physics, chemistry and biology education.

Science at school

Children, at the age of twelve, have to choose between vocational education (in Dutch: LBO, about 40%) and general education at the end of primary school. Pupils are to choose their final subjects when fourteen years old (voc. ed.), or when fifteen or sixteen (gen. ed.). I'd like to refer to Ilja Mottiers's and Magda Man in't Veld's contributions to the GASAT conferences for an explanation of our Dutch school system.

The percentage of pupils choosing the following subjects in the three streams of gen ed. as laid down by CBS in 1985 (Central Bureau of Statistics) is:

		% BOYS	% GIRLS
MAVO 77208 pupils			
	math	79	46
	phys	58	**13**
	chem	57	37
	biol	36	61
HAVO 50487 pupils			
	math	73	42
	phys	51	14
	chem	46	32
	biol	39	54
VWO 35775 pupils			
	math(1)	82	59
	phys	64	**28**
	chem	56	35
	biol	41	48

The low percentage of girls choosing **physics** immediately meets the eye. Two other remarkable features are that more girls than boys opt for biology and that more than half of the girls, on an average, do not choose mathematics. The combination and composition of final subjects is determining for entry into all kinds of continuation-training and professions.

Very many training-schools require mathematics, even in the case of politicology, domestic economy, and applied didactics. It appears as if mathematics as such is used as a determining means.
Physics is compulsory for various technical, agricultural and medical training centres. Physics cannot be taken up in the syllabus without mathematics.
Chemistry is obligatory for many agricultural, medical and paramedical fields.
Biology, though not mentioned under compulsory subjects is still expected to be studied, which in fact is taken for granted by everybody in the continuation training-centres.

Common causes

The statistical figures show that the Netherlands definitely do not lead the field when it comes to women emancipation, compared to USA or the other European countries. Here are some figures to illustrate this: In 1986 35.6 % of paid labour was done by women, 50 % of the women in part-time jobs, whereas only 5 % of the men were active in part-time jobs.
At management and other highly qualified levels only 5 % of the leading jobs is executed by women; to give an example: one out of sixty architects or engineers is a woman.

As a consequence hardly any women are to be found at all kinds of policy-making levels. This is true for both paid and unpaid jobs and as a matter of fact increasingly so for institutions dealing with science and technology. Among physics teachers less than 10 % is female, which percentage won't be much higher among authors of text-books and developers of curricula.

Fortunately, we've got a male Minister of Education backed up by a female Secretary (who is not writing his letters but pointing out policy lines as well). She largely contributes to the improvement of the position of women and girls in the field of education.

Owing to shortage of money, the Ministry of emancipation was discontinued in its work so that now emancipation is

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again a matter of "partial policy" which implies that everybody is trying to get a piece of the financial cake, without there being one overall policy line.

The tasks of the committee

1 mutual contact

The committee mainly consists of people who in their own environment are active in stimulating girls and women in taking science or in creating better conditions thereto.

One of the committee's tasks, therefore, is a regular contact and a mutual motivation. Almost everybody does this work in his spare time next to a job and often other activities. Many GASAT visitors know how difficult it is to restrain oneself once one has begun to be an active member.

At the meetings (four times a year) one of the members is to deliver a lecture on her or his activities in this field, so that we may learn from each other. If our presence or our interference anywhere is asked for, we can inform each other of this.

Finally, governmental policies as to making one of the science into compulsory subjects may be discussed, or the abolition of chemistry in the lower forms. As soon as we have come to a well-founded, communal standpoint, this will be made known to the institutions involved. The latter comes under the heading, our main job.

2 Our main job

To change in fact the low percentage of girls taking science in their syllabuses, we must try and make people at all sorts of levels aware of this problem, and then offer suggestions leading to possible improvements.
Therefore, articles of all kinds are published in the Science Teachers Monthly Magazine and other magazines, shop meetings and congresses are attended and workshops and lectures are being held.

At the moment we are working on a new pamphlet and poster, aimed at pupils, teachers and deans.

A list of recommendations was put up for notably authors and publishers of textbooks but also for teachers in order to make sure that learning material had to fulfill the needs both of girls and boys. Existing learning methods are being judged according to these criteria at present.

In April 1985 the committee organized a day in cooperation with NVON. The lectures and workshops were well-attended and highly appreciated. A concomittant effect was that the ties with NVON and other institutions were tightened, so that from that time onwards our advice and cooperation in more subjects is being asked for, for instance the taking part in committees etc.

Our committee is also active at a policy level, cf. post-graduate work development of curricula and new examination programmes. These, among others, are considered to belong to our strategic tasks.

4 *Strategic tasks*

One of the ways to make our voice heard at a government level is via the Emancipation-Council. This Emancipation Council has as its task to advise the Government on the emancipation policy. Ministers are obliged to ask the advice of the Council on all major issues.

In this way our advice on the new programme for physics exams for LBO-MAVO was taken up almost entirely into the Emancipation Council's advice to the Minister.

At the moment, partly via Emancipation Council and partly by way of NVON our commentary on the WRR memorial, (a government proposal to come to another form for education in the first three years after primary school) is being given out. One of the aspects of the commentary will be on the founding of committees who are to ascertain the definite contents of this new sort of education.

We urgently request for an ample number of women and emancipation experts in these committees.

Besides, we try to get representatives of our committee in all fields of academic and non-academic circles. The diversity of our group appears to be of great advantage, although these people (mainly women of course) sometimes have to cope with feelings of hesitation and innate shyness.
This fact should not be underestimated. Formerly it often appeared that a function offered was not accepted by anyone. Nowadays we ask someone for such a job directly, and pronounce our trust in him or her, which resulted in some people showing excellent ability in coping with the job, after first thinking of their own incapability. It is clear then that it is better to ask someone specifically for a job and to pronounce everybody's confidence than to offer a job in an open procedure without anybody applying for the job.

Maybe my own membership of WEN (dealing with HAVO/VWO examination programmes) can be offered as an example of the above-mentioned procedure.

WEN

WEN (short for Werkgroep Examenprogramma's Natuurkunde) obtained a Ministerial commission to try and revise the final examination programmes for physics for all secondary education.
A very important task!

One of the items mentioned in this commission was to open up the subject of physics to girls. As the only woman among thirteen WEN members I took on me the task of focusing special attention to those specific subjects which make physics more or less attractive to girls. An ambition in which I am backed up by the other members of our group.
Of course I can consult the physisians of the Committee for Women and Science

Within the WEN there was a reasonable consensus as to the changes (not only for girls) that have to take place. For example more "environmental physics", secondly more applied physics" knowledge and thirdly more contextual knowledge of physics.

So for instance we have done away with a considerable amount of theoretical electrostatics and electromagnetical calculating. **Biophysics** is taken up as a new subject together with the safety aspects of ionizing radiation and the medical applications.
Electronics is another new subject, unfortunately little appealing to girls: in 1985 only 29 girls were studying electrotechnics at Univerity level on a total number of 3116 boys. There is only one way of getting rid of this discrepancy in numbers namely to take up the subject from the very start.

As an example of contextual physics WEN had to think of new elements in the chosen subjects, since the interests and experiences of boys and girls widely differ. So for instance music and echoscopy comes under the heading of sound waves, and natural circulation in living spaces is discussed when heat transport is treated. The latest item we try to get into our programme is information technology. Whether this will be at the cost of electronics, biophysics or another subject is still a matter of discussion.

De Bilt, March 1987.

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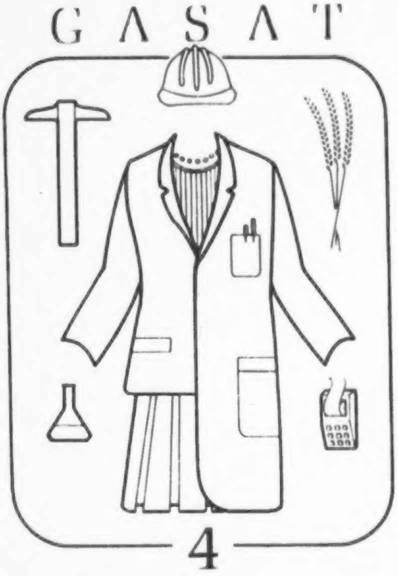
GIRLS AND SCIENCE AND TECHNOLOGY



ADDENDUM

CONTRIBUTIONS TO THE FOURTH GASAT CONFERENCE

July 24-29, 1987
The University of Michigan, Ann Arbor, Michigan U.S.A.

Edited by Jane Z. Daniels Jane B. Kahle

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Parents as Socializers of Achievement Attitudes

J.Eccles, C.Flanagan, R.Goldsmith, J.Jacobs, T.Jayaratne
A.Wigfield, and D.Yee

Institute for Social Research, University of Michigan

Parsons, Kaczala, and Adler (1982) found that parents' math-related beliefs have a strong influence on junior high schoolers' perceptions of their own math abilities, perceptions of the value of math, future expectations, and course plans. Parsons et al also documented the role parents play in perpetuating sex differences in junior high schoolers beliefs about mathematics. Building on this work, this paper examines the role parents play in shaping sex differences in children's achievement beliefs in three separate studies. Study 1 provides a replication of Parsons et al., (1982) on a more diverse age range (grades 5-12 instead of grades 7-9). Study 2 relates sex differences in parental beliefs to sex differences in parents' causal attributions for their children's math performance. Study 3 provides a comparison of parental influence in math and English and examines the joint influence of parental beliefs for each of these academic subjects on children's beliefs for each subject.

Study 1: Approximately 300 children in grades 5-11 and their parents participated. Children's attitudes were assessed in their classrooms; parents' attitudes were collected with a mailed questionnaire. The results are displayed in Study 1: Table 1. Consistent with the findings of Parsons et al., (1982) parents of sons held more positive beliefs regarding both their child's math abilities and the importance advanced level math courses have for their child than did parents of daughters, despite the fact that there were no sex differences in the children's math grades and performance on standardized tests. In addition, the parents of daughters rated English as more important and rated their child's general school performance as better than did parents of sons. Finally, consistent with Parsons et al., (1982) path analyses indicated that these parental perceptions of their child's math ability and ratings of the importance of various subjects have a stronger influence on children's self-perceptions and task perceptions than they do children's academic grades.

Study 2: Study 2 examined parents' attributions for their child's math performances. Approximately 80 parents were asked, in a home survey, to rate their child's math abilities and to make causal attributions for their child's successes and failures on math tests. The results are displayed in Study 2: Tables 1-3. Both the child's math ability level (based on school records and class assignments) and the sex of child affected parents' perceptions of their child's math ability, performance and effort and parents' attributions for their child's math success to effort and talent. Consistent with Study 1, and with the results of Parsons et al., (1982), mothers of boys rated their child's relative math talent higher than mothers of daughters. Conversely, mothers of girls rated their child's effort in math higher than did mothers of sons. In addition, fathers of sons set a higher relative performance standard for their child and were less likely to believe that their child was doing as well as possible than fathers of girls.

Each of these differences exist despite the fact that there were no actual performance differences between the boys and girls in this sample. Why might this be so? Attribution theory suggests that causal attributions for success and failure influence the inferences one draws from one's experiences. If parents make differential interpretations for boys' and girls' math successes then parents may develop different views of their sons' and daughters' math competence despite similar school performance information. As a first step toward testing this reasoning, we compared the causal attributions these parents made for a recalled math success and a recalled math failure for their child. Parents rated the importance of each of the causal attributions listed in Study 2: Tables 1 and 2 on a 7-point scale ranging from not at all important to very important. Parents, especially mothers, of boys rated talent as a relatively more important reason for their sons' math successes than parents of daughters; in contrast, parents, especially mothers, of girls rated effort as a relatively more important reason for their daughters' math successes than parents of sons. These results suggest that parental attribution differences may underlie parents' sex-differentiated perceptions of their children's' math abilities.

To test this hypothesis more directly, we correlated parents' attributions with their perceptions of their children's math ability. Attribution theory suggests that attributing success to talent should have a positive effect on perceptions of one's child's math ability; conversely, attributing success to effort should have a negative impact on perceptions of one's child's math ability since effort and ability are typically considered to be compensating causes. As is clear in Study 2: Table 3, the relationship between parents' causal attributions for their children's math successes and parents' rating of their child's effort and talent confirm these predictions. This pattern of relationships could explain why parents perceive their daughters as being less able in math than sons despite the fact that boys and girls get equivalent grades and test scores in both of these samples.

Study 3. Study 3 was designed to look at the joint impact of parental beliefs about their child's math and English ability on early adolescents', self and task perceptions in both subject area. Data from Study 1 suggested that parents may have subject-matter stereotyped beliefs regarding their children's abilities. To test this hypothesis and to assess the impact of these gender-role stereotyped beliefs on their children's beliefs, the beliefs of approximately 1500 parents regarding their children's math and English achievements on 7-point Likert-type scales were compared.
There were consistent subject matter by sex of child interactions (See Study 3: Figures 1-4). Parents of girls rated their child's English abilities more positively than her math abilities, despite the fact that the girls had been getting equivalent grades in math and English; parents of girls also rated English skills as more important for their child than math skills. Parents of boys showed the opposite pattern for both sets of beliefs. Contrary to what one might expect given the current concern over girls and math, sex of child

effects were more marked for English than for math and subject matter effects were more marked for boys than for girls.

To assess the impact of parental beliefs on children's self perceptions, these beliefs were entered as lagged predictors of the children's subsequent self-perceptions in a path analysis. Mothers results are depicted in Study 3: Figure 5 and 6. The mothers' beliefs and the teachers' rating of the children's math ability were assessed in the fall while the child's self-perceptions were gathered in the spring. Fathers' data yielded comparable patterns. These path analyses (Study 3: Figures 5 and 6) document the general impact of mothers' beliefs on children's math and English self-perceptions. Consistent with the findings of Parsons et al., (1982) mothers' ratings of their child's math ability had a positive and significant effect on the children's subsequent math and English self perceptions. In addition mothers' ratings seemed to mediate the impact of teacher's ratings on the children's confidence in their own math ability and interest in math.

The path also documents an interesting across subject area suppression effect. Parents' ratings of their child's English abilities had a negative impact on the children's math ability self-perceptions after holding the children's math performance constant. This finding suggests that girls' confidence in their math ability is being undermined by two parental beliefs: First it is being undermined by the fact that parents over estimate how difficult math is for daughters; and, second, it is being undermined by parents' high ratings of their daughters' English abilities.

These results will be discussed in terms of gender role socialization and in terms of more general parental influences on children's achievement beliefs. As a result of the patterns of data reported, it seems probable that parents may try to steer boys and girls into different academic courses and into different occupations; courses and occupations that capitalize on what the parents believe are their children's strongest intellectual abilities. And, in fact in both Study 1 and Study 3, parents reported that they believe

English literature is more important for their girls and feel they would be more likely to encourage boys to take advanced math courses (See Study 1: Table 1).

This research was made possible by grants from the National Institute of Mental Health (MH31724 to Jacquelynne S. Eccles), the National Institute of Child Health and Human Development (HD17296 to Jacquelynne S. Eccles), the National Science Foundation (BSN-8510504 to Jacquelynne S. Eccles and Allan Wigfield) and the William T. Grant Foundation (83-0917-00 to Jacquelynne S. Eccles). Address correspondence and requests for reprints to J. S. Eccles, 5207 Institute for Social Research, The University of Michigan, Ann Arbor, Michigan 48106.

Study 1

Table 1

Mean differences (student t) between parents of daughters and parents of sons
on selected parent-child variables

variable	Mothers			Fathers		
	Daughters	Sons	p	Daughters	Sons	p
Perception of child's math ability (scale)	52.8	54.8	.05	51.4	52.1	n.s.
Perception of child's effort in math (scale)	43.2	40.0	.01	45.7	43.3	.05
Perception of child's difficulty in math (scale)	39.3	35.5	.01	41.3	39.0	.05
Importance of math for child (scale)	55.0	57.0	.01	54.8	56.1	n.s.
Perception of child's perception of importance of math (scale)	55.8	55.9	n.s.	53.4	53.1	n.s.
Future expectancy in math for child (scale)	55.1	56.3	n.s.	55.2	55.0	n.s.
Trigonometry/calculus important for child	4.8	5.4	.001	5.0	5.6	.0001
Geometry important for child	5.7	5.9	n.s.	5.5	5.7	n.s.
Chemistry important for child	5.3	5.6	.05	5.3	5.4	n.s.
Child enjoys math	5.3	5.5	.05	5.1	5.2	n.s.
Child thinks math learned in courses useful in future	5.4	5.7	.05	5.1	5.4	.05
Child doing as well as possible in math	5.5	5.2	n.s.	5.3	4.9	.05
Strongly encourage child to take math	5.2	5.7	.05	5.3	5.7	n.s.
Satisfied with child's math education	5.3	5.3	n.s.	5.0	5.2	.05
English literature important for child	5.8	5.5	.01	5.3	5.0	.05
Child feels important to do well in school	6.3	6.1	.01	6.2	4.6	.0001
Child doing well in academic subjects	6.1	5.7	.0001	6.1	5.6	.0001

NOTE: Unless otherwise indicated, variables are indiviual questions asked of parents about their daughters or sons.

- : t was non-significant.

Study 2

Table 1

Impact of child's math ability level on parents' math achievement-related perceptions and expectations

Variable	Mothers*				Fathers‡		
	High	Average	Low	F-ratio	High	Average	F-ratio
General school performance	6.31	5.38	4.19	16.75[4]	5.94	5.31	3.93[1]
Current math performance	5.94	4.75	3.69	11.13[4]	5.94	4.88	12.57[3]
Future math performance	6.25	5.31	4.44	8.15[3]	6.06	5.19	1.89[2]
Maximum standard	13.13	12.63	11.44	12.50[4]	13.06	12.81	2.95†
Minimum standard	9.63	9.19	8.69	......	9.75	9.00	....
Relative minimum standard	2.06	1.94	1.88	......	2.13	1.81	....
Required effort	3.81	4.50	4.56	......	3.75	4.88	4.93[1]
Relative effort	1.81	2.19	2.25	2.47†	1.94	2.13	....
Talent	5.88	4.81	4.13	12.40[4]	5.69	5.00	5.68[1]
Relative talent	2.38	1.88	1.88	3.73[1]	2.06	2.06	....
Doing as well as possible	3.31	2.69	2.38	5.95[2]	3.31	3.00	....
Success attributions							
Talent	5.63	4.50	3.69	7.77[3]	5.63	4.81	3.83†
Enjoyment	5.56	4.88	4.44	......	4.88	4.44	....
Effort	4.63	5.75	5.69	3.18[1]	5.19	5.19	....
Task easiness	3.19	3.13	3.88	......	2.81	3.87	3.10†
Teacher help	4.75	5.13	5.56	......	4.25	5.25	3.41†
Parent help	2.13	2.06	4.00	7.08[3]	1.75	2.63	....
Good day	2.94	3.75	4.13	......	2.67	3.19	....
Failure attributions							
Lack of talent	2.00	2.88	3.50	3.00†	1.53	2.38	4.53[1]
Lack of enjoyment	2.60	3.31	3.94	......	2.40	3.50	2.97†
Lack of effort	4.93	5.31	5.50	......	5.67	4.94	....
Task difficulty	3.86	4.13	4.53	......	3.13	4.31	3.67†
Lack of teacher help	2.80	3.50	4.69	2.84†	2.79	3.25	....
Lack of parent help	2.73	2.56	4.94	6.92[3]	2.28	2.50	....
Bad day	3.20	3.06	3.80	......	3.07	2.94	....

Note: F-ratios are derived from 2-way ANOVAs with child math ability level and child sex as independent factors.
Items regarding maximum and minimum grade standards are coded from 1 (F) to 14 (A+). Items about relative minimum standard, relative effort, and relative talent are rated on 3-point scales. The item about performance matching potential is rated on a 4-point scale. All other items are rated on 7-point scales.

*N's range from 46 to 48
‡N's range from 30 to 32
†$p \leq .10$
[1] $p \leq .05$
[2] $p \leq .01$
[3] $p \leq .001$
[4] $p \leq .0001$

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Table 2

Impact of child sex on parents' math achievement-related perceptions and expectations

Variable	Mothers·			Fathers‡		
	Girls	Boys	F-ratio	Girls	Boys	F-ratio
General school performance	5.50	5.08	......	6.06	5.19	7.71[2]
Current math performance	4.83	4.75	......	5.69	5.13	3.52†
Future math performance	5.33	5.33	......	5.81	5.44	......
Maximum standard	12.25	12.54	......	13.06	12.81	2.95†
Minimum standard	9.04	9.29	......	9.19	9.56	......
Relative minimum standard	1.96	1.96	......	1.63	2.31	11.93[2]
Required effort	4.83	3.75	6.52[2]	4.25	4.38	......
Relative effort	2.38	1.79	11.25[2]	2.19	1.88	......
Talent	4.71	5.17	......	5.31	5.38	......
Relative talent	1.83	2.25	5.83[1]	2.00	2.13	......
Doing as well as possible	2.83	2.75	......	3.47	2.88	5.81[1]
Success attributions						
Talent	4.21	5.00	3.86[1]	5.19	5.25	......
Enjoyment	4.63	5.29	......	4.88	4.44	......
Effort	5.75	4.96	3.74[1]	5.56	4.81	......
Task easiness	3.63	3.17	......	2.73	3.88	4.50[1]
Teacher help	4.88	5.42	......	5.06	4.44	......
Parent help	2.67	2.79	......	2.00	2.38	......
Good day	3.71	3.50	......	2.57	3.25	......
Failure attributions						
Lack of talent	3.09	2.54	......	1.60	2.31	3.30†
Lack of enjoyment	3.57	3.04	......	3.40	2.56	......
Lack of effort	5.43	5.08	......	5.33	5.25	......
Task difficulty	4.65	3.70	3.47†	3.73	3.75	......
Lack of teacher help	3.52	3.83	......	3.16	2.94	......
Lack of parent help	3.48	3.38	......	2.14	2.63	......
Bad day	3.30	3.39	......	2.86	3.13	......

Note: F-ratios are derived from 2-way ANOVAs with child math ability level and child sex as independent factors.
Items regarding maximum and minimum grade standards are coded from 1 (F) to 14 (A+). Items about relative minimum standard, relative effort, and relative talent are rated on 3-point scales. The item about performance matching potential is rated on a 4-point scale. All other items are rated on 7-point scales.
·N's range from 46 to 48
‡N's range from 30 to 32
†$p \leq .10$
[1]$p \leq .05$
[2]$p \leq .01$

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j1 08

Table 3

Mothers' success attributions and math-related perceptions.

Math-related Perceptions	Success Attributions	
	Talent	Effort
Required effort	-.34[3]	.30[2]
Relative effort	-.54[4]	.52[3]
Talent	.67[4]	-.43[3]
Relative talent	.42[3]	-.50[4]

Note: Relative effort and relative talent items are rated on 3-point scales. All other items are rated on 7-point scales.

[1] $p \leq .05$
[2] $p \leq .01$
[3] $p \leq .001$
[4] $p \leq .0001$

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Study 3

Figure 1

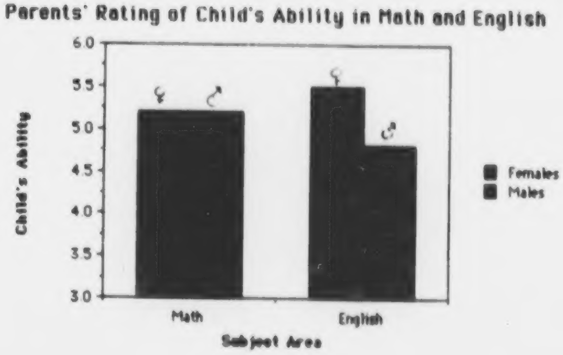


Figure 2

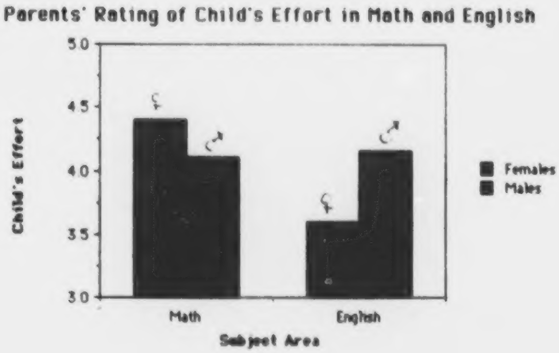


Figure 3

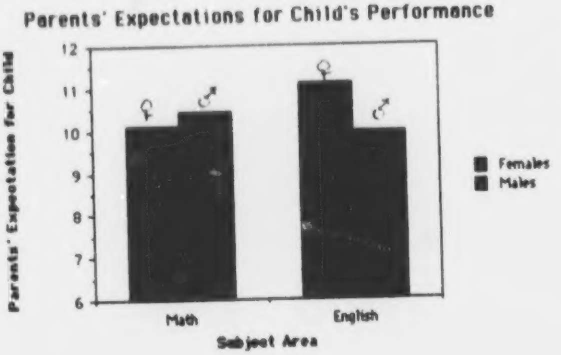
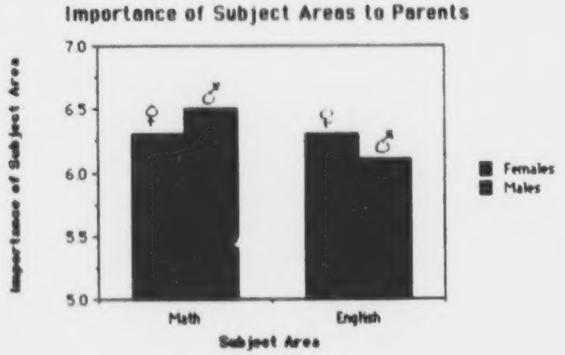
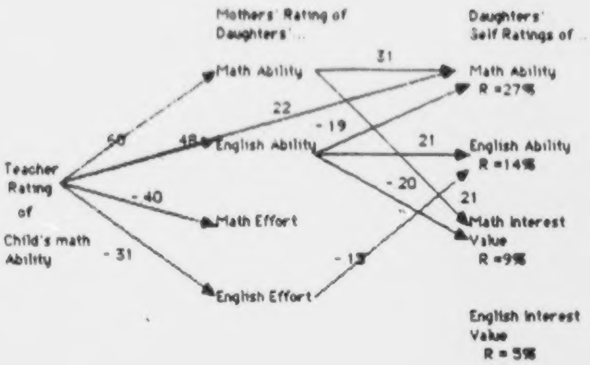


Figure 4




Mothers' Rating of Daughters'...
Daughters' Self Ratings of...
Math Ability
English Ability
Math Effort
English Effort
Teacher Rating of Child's math Ability
60
48
22
-40
-31
31
-19
21
-20
21
-13
Math Ability R =27%
English Ability R =14%
Math Interest Value R =9%
English Interest Value R = 5%

N=920

FIGURE 5. Mothers' Influence on Daughters' Self-Perceptions

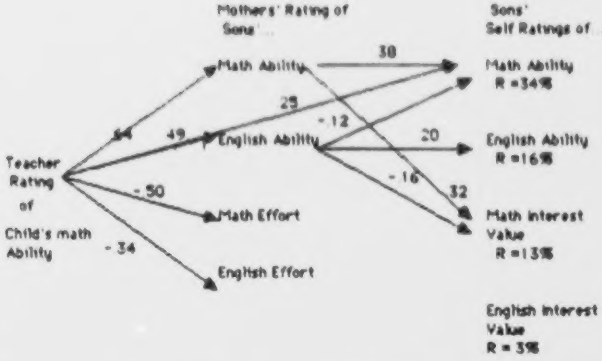

Mothers' Rating of Sons'...
Sons' Self Ratings of...
Math Ability
English Ability
Math Effort
English Effort
Teacher Rating of Child's math Ability
64
49
25
-50
-34
38
-12
20
-16
32
Math Ability R =34%
English Ability R =16%
Math Interest Value R =13%
English Interest Value R = 3%

FIGURE 6. Mothers' Influence on Sons' Self-Perceptions

n=920

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13

Sex Differences in Children's Motivation and Enagement in Science

Judith L. Meece, Daria Courtney, & Phyllis Blumenfeld

University of North Carolina & University of Michigan

Previous research has suggested that girls develop a set of motivational characteristics that are maladaptive for high levels of achievement in math and science (see Dweck, 1987; Fennema & Peterson, 1985; Steinkamp, 1984). In a recent review of this research, Dweck (1987) reported that, in contrast to boys, girls express less confidence in their abilities, attribute failure to a lack of of ability, and show less persistance in the face of difficulty. Due to their lower sense of competence, girls tend to be primarily motivated to perform academic tasks to gain social approval, while boys engage in activities to increase their sense of mastery and control. This analysis does not suggest that boys are more motivated than girls. Rather, boys and girls are motivated by different needs for approval, competence, and control which can influence their motivational orientation in the classroom.

It is further suggested that gender differences in students' motivational orientations can also influence their preferences for different types of academic tasks and their selection of problem solving strategies. Girls tend to prefer highly structured, rote-type tasks in which there is less chance of failure. They also prefer tasks where praise, reward, and reinforcement are frequently and readily available because of their greater need for social approval and external judgments of competence. Boys, on the other hand, tend to prefer complex and challenging tasks in which they can test and develop their competence. They are more willing to engage in competitive activities and to take risks in the form of attempting difficult solutions, proposing unique ideas, and breaking away from problem solving approaches used by the teacher or other students. Therefore, in contrast to girls, the motivational orientations boys exhibit are assumed to facilitate the development of those problem solving, risk taking, and autonomous learning behaviors needed for success in math and science especially at the higher grade levels.

While previous research has identified a set of motivational factors that may impede the success of girls in science, much of this work is based on laboratory studies. The influence of these gender differences have not been adequately examined in classroom settings. Our earlier work has shown that different learning situations in the classroom can moderate the influence of learner characteristics (see Meece & Blumenfeld, 1987). The purpose of this study was to examine the effects of gender on students' patterns of motivation and engagement in elementary science activities. The following questions were addressed: (1) Do boys and girls report different patterns of motivation and cognitive engagement in science activities? (2) Are these patterns of motivation and cognitive engagement consistent across science activities of differing structure and cognitive complexity?

Description of Study

This study is based on 105 male and 108 female students from 10 fifth and sixth grade classrooms located in middle class schools and taught by experienced teachers (3 females and 2 males). Toward the beginning of the 1985 academic year, children completed a set of questionnaires designed to assess their entering perceptions of competence, intrinsic motivation to learn in school, and attitudes toward science. Achievement test scores were also collected from school records.

In collaboration with each teacher, six science lessons per class were selected for observation and data collection. Lessons were choosen from three different units so that several topics were represented including the human body, forms of energy, and space travel. Lessons also varied with regard to difficulty level, social organization, and use of manipulatives or laboratory materials.

Students in each class completed a short questionnaire following the six lessons we observed in each classroom. Items on this group administered questionnaire were designed to assess children's goal orientations, cognitive engagement, and task specific expectations. Based on previous research (e.g., Ames, 1984; Dweck & Elliot, 1983; Nicholls, Patashnick, & Nolen, 1985) the following goal orientations were examined in this study: (a) *mastery-oriented*, in which students seek to independently master material, to understand, or to purposively engage themselves in the learning activity; (b) *ego-enhancement*, in which students seek to compete with others, to obtain social approval, or to please the teacher; and (c) *work-avoidant*, in which students seek to minimize effort or to avoid negative evaluations from others. Another set of items were included in this questionnaire to distinguish superficial from mastery oriented forms of cognitive engagement. Items tapped cognitive strategies and dimensions of self-regulated learning such as attention, planning, connecting, monitoring, along with help seeking and work avoidant strategies. The instruments used in this study are more fully described in a recent study by Meece and Blumenfeld (1987).

Results and Discussion

Do boys and girls report different patterns of motivation and engagement in elementary science activities? Our earlier research indicated that individual differences in students' self-perceptions of academic competence and intrinsic motivation were important predictors of their goal orientation in the classroom. Therefore, these variables were first examined for gender differences. The measure of intrinsic motivation used in these analyses was specifically designed to assess the degree to which students generally mainifest an intrinsic interest in learning, view themselves as curious, and show a preference for challenging work or for opportunities to master things on their own. Contrary to the suggestions of previous research, girls in this study did not report less intrinsic motivation to learn than boys. In addition, no gender-related differences were found in students' ratings of their academic competence, attitudes toward science, or task specific performance expectations. The only difference found in these general measures of motivation suggested that girls had lower perceptions of their science abilities than boys, even though no differences were found in their science grades or achievement scores. It is important to point out that there were significant differences in the ratings of fifth and sixth grade students on many of these variables. The findings indicate a downward trend in students' perceptions of abilities, intrinsic motivation, and attitudes toward science.

Our next set of analyses examined the effects of gender and grade level on students' goal orientations and patterns of engagement during science lessons. Significant differences were found in boys' and girls' goal orientations, but these differences were influenced by grade level as well. Fifth grade students reported a stronger mastery orientation than sixth graders, indicating that their goals were to understand and master the activity. Fifth grade boys were more mastery oriented than any other group. Significant grade level differences were also found in students' ego-oriented and work-avoidant goals, with sixth graders placing a stonger emphasis on these set of goals. Finally, a main effect for gender indicated that boys were more oriented than girls toward goals that involved seeking recognition or minimizing effort. However, a significant sex-by-grade interaction indicated that sixth grade girls were more concerned about external evaluation than any other group.

Our analyses of students' reported engagement in these activities revealed a similar set of findings. A main effect for gender was not found in the measure of cognitive engagement indicating use of higher processing skills. Contrary to the research reported earlier, boys tended to be more superficially involved than girls in these science activities, based on their reported use of effort minimizing and work avoidant strategies. These findings are consistent with the sex differences found earlier in students' ego-oriented and work-avoidant goal orientations. Students who adopt these goal orientations are more likely to show a lower form of engagement in classroom activities.

Are these patterns of motivation and cognitive engagement consistent across science activities of differing cognitive complexity and structure? The next set of analyses involved testing the effects of different learning conditions on students' motivational patterns and cognitive engagement in science activities. On the basis of previous research, it was predicted that boys and girls would respond differently to science activities that involved cognitively demanding material or that were less structured, with girls showing a lower form of engagement in these types of activities.

To form the sample for these analyses, we identified a set of teachers who had taught science activities that were approximately similar in terms of difficulty level and lesson format. This limited our analyses to six science classes taught by three different teachers. We then contrasted the effects of difficulty level on students' mean scores on the goal orienttion and cognitive engagement measures. Lessons which primarily emphasized knowledge and comprehension skills were categorized as low (n=9); lessons above this level on Bloom's taxonomy were coded as high difficulty (n=8). Analyses were performed on teacher-led whole class activities in which students were required to complete an individual assignment (e.g., worksheet, graph, written answers to questions, etc.) by the end of the period. A marginally signficant interaction effect indicated that girls were more strongly influenced by the difficulty of the lessons. However, contrary to our predictions, girls reported a stronger mastery orientation than boys in the high difficulty tasks. No gender differences related to the difficulty of the task were found in students' scores on the engagement scale indicating use of high level processing skills.

We also examined variations in students' goal and engagement ratings related to lesson format. Previous research indicated that small group "hands on" activities that involve inquiry and investigative skills tend to be less teacher structured and place the burden on students to regulate and manage their own learning process. To test for effects related to the structure of lessons, we contrasted the effects of inquiry-type activities (n=10) versus whole class activities (n=8) using lessons that were categorized as high difficulty to control for the effect of this factor.

The results indicate that boys and girls were not differentially influenced by the structure of the lesson. In general, students reported a stronger mastery orientation but less cognitive engagement in small group activities. The findings further indicated that students of some teachers were more cognitively engaged in these activities, regardless of format. Effects due to teacher were not gender differentiated.

Conclusions

The present study provided little support for the gender differences in motivational processes and task engagement patterns proposed in earlier research. Overall, girls did not report less intrinsic interest and lower forms of engagement in the science activities we observed in fifth and sixth grade classrooms. Furthermore, boys and girls were not differentially influenced by different characteristics of the learning activity such as its degree of difficulty or structure.

Our data point to the importance of placing gender differences in a developmental context. The results lend support to other studies (e.g., Eccles, 1983; Harter & Connell, 1984) indicating developmental declines in studnts' self-concepts of abilities, attitudes toward various subject areas, and intrinsic motivation. It has been suggested that these developmental changes stem in part from children's increased ability to integrate normative and social comparison information in forming estimates of their own ability levels. As a result, they become more ego-involved in academic tasks, expressing more concern about the evaluations of others while, at the same time, putting less effort in these activities as a way of maintaining high perceptions of ability (Nicholls & Miller, 1984; Miller, 1985).

Data reported in this study support these general developmental trends. Fifth graders were more mastery-oriented that sixth graders; sixth graders were more strongly motivated to engage in science activites for external approval. In addition, sixth graders reported using more work avoidant and effort minimizing strategies.

The findings also indicate that sex role socialization may contribute to these developmental transitions as well. Previous research has shown that as gender role socialization intensifies in the early adolescent years, students become more sex-typed in their achievement attitudes and behavior (Eccles, 1983; Hill & Lynch, 1983). The preadolescent years are also considered to be a stage of growing self-awareness and need for social approval as students begin the physical changes associated with puberty. Therefore, older students are more likely to conform to sex role expectations.

Evidence of this sex-typing effect was found in this study. Girls rated their science ability lower than boys, despite the fact that no differences were found in their overall sense of academic competence, science achievement, or forms of task engagment. Boys, on the other hand, reported a greater work avoidant orientation than girls. Boys may report more use of effort minimizing strategies as a way of maintaining high perceptions of ability or disguising low ability in a subject area that is traditionally viewed as a male activity. Alternatively, boys may engage in more work avoidant behaviors, regardless of subject area, as a way of resisting the authority of their teachers and maintaining their independence in the classroom. The impact of this behavioral pattern is not clear. If it reflects a more autonomous learning style, as research has suggested (e.g., Fennema & Sherman, 1985; Steinkamp, 1984), it may be an advantage for later achievement when independent problem solving and work habits are more highly valued

Additional research on gender differences in motivational processes needs to be done in classroom settings. Classrooms differ considerably in the situational factors that elicit sex differentiated behavioral patterns (Meece, in press). Longitudinal studies are also needed to identify the developmental origins of sex differences in achievement-related beliefs and behaviors. As other researchers have suggested, the early adolescent years appear to be a critical period for this gender differentiation.

This study offers several suggestions for teachers. As students approach adolescence, they become more concerned with external evaluation and social approval which can undermine their intrinsic motivation in the classroom. Steps should be taken to minimize public praise and criticism, competition, and social comparison. These factors have been found to heighten students' evaluation concerns. Studies have also indicated that these classroom practices may be especially negative for girls (Kahle, 1984; Parsons, Kaczala, & Meece, 1982). The greater work avoidant orientation of older students suggests an increased need for student control and autonomy in learning activities. Too often, teachers respond to these bids for autonomy with stricter control rather than helping students to find more appropriate ways of managing and regulating their own learning process. In addition, the results of our second set of analyses indicate that some teachers were more effective than others in promoting a mastery orientation toward learning in the classroom. Future research will involve examining lesson transcripts to identify how these teachers created a social and intellectual climate in their classrooms promotive of problem solving and inquiry.

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WOMEN IN SCIENCE AND TECHNOLOGY IN AUSTRALIA (WISTA) : THE INFLUENCE OF INSTITUTIONAL ECOLOGY

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INTRODUCTION

The Women in Science and Technology in Australia (WISTA) project focusses not on secondary schooling (like, for example the British GIST project) but on the role of higher education institutions in helping the access and progression of women. WISTA has four main aims :-

(i) the improved diagnosis and understanding of key factors which serve as critical filters to discourage female enrolments in scientific and technological disciplines in higher education institutions in Australia; and of factors supportive to their enrolment and retention : that is, an access question.

(ii) an improved understanding of their implications for the schooling, tertiary and careers guidance systems : that is, a learning and teaching issue.

(iii)an improved understanding of the relationship between school curricular options, female tertiary choices and female labour market participation: that is, a policy issue.

(iv) the improved identification of institutional ecology of different higher education institutions and its influence on women's performance and motivation, in the specific context of advising on future policy changes : that is, a research and policy issue.

Objectives include the production of midrange theory and of an improved theoretical model for examining the role of institutional ecology. The WISTA project works through three strands of research, a **study of working women scientists and technologists** with a focus on their educational experiences in school and tertiary education; a **longitudinal study of women undergraduate and potential postgraduate students** in two Sydney higher education institutions; and a **policy review study of five Universities and five Institutes of Technology** in Australia. This paper refers only to the work of the policy review strand and discusses briefly the development of an improved model for examining the influence of institutional ecology in relation to women's achievement and progression in higher education.

Theoretical framework : a theory grid

Our approach has its roots in the "grounded theory" strand of educational research, and works through a theory grid in which the focus is on the point of interaction between several fundamental concepts and a number of key factors of influence. That is, the researchers start from a premise that the key determinant of women's behaviour (and that of their teachers and lecturers) is either a cluster of factors, or the interaction process of these. A second key assumption is that whatever the demerits of the schooling process, higher education institutions have (a) the capacity to remediate these and (b) a direct responsibility to do so.

The vertical elements of the grid, as it were, are some concepts, or perhaps constructs, which we consider need further review. The four key ones are (i) institutional ecology; (ii) the concept of "critical mass"; (iii) the social or educational sex-labelling and marketing of individual disciplines as "male" or "female" or sexneutral; and (iv) the structure, content and style of different areas of science and technology (eg as objective or subjective; as socially destructive or responsible; as intellectually free-wheeling or as system-based and applied).

Against this, a "horizontal" meshing is investigated of ten core factors which both our review of earlier research, and the early WISTA work, have isolated as common to most cultures and countries which have recorded publicly available research. That is :-

- same sex role models as a positive factor of influence for women;
- the mentor process as a potentially negative or positive influence;
- the image of different branches of science and technology (male, female or sexneutral; socially responsible or systems and machine-oriented);
- male attitudes to females in "non-traditional" disciplines; female attitudes (self-esteem, or towards peers);
- single sex versus coeducational learning environments as positive or negative influences;
- prerequisites and school patterns of curricular choices as critical filters;
- mathematics as a critical filter;
- careers education and vocational counselling as positive or negative influences;
- women's support networks as positive influences;
- affirmative action projects in science and technology as positive influences.

Diagram A below illustrates the interlocking design :-

	Institutional Ecology	Critical Mass	Male or female attribution of discipline	Structure, content & style of science & technology
same sex role models	○	○	○	
mentors	○		○	
image of sciences	○		○	○
male & female attitudes	○		○	
single sex v. coeducational learning environment	○	○		
prerequisites & curricular choice			○	○
maths as a critical filter			○	
careers education & vocational guidance	○		○	
women's support networks	○	○		
affirmative action	○	○		

Here, we have only noted those interaction points established so far by WISTA analyses. For example, the presence of same-sex role models is potentially part of the overall institutional ecology, and to the extent that the earlier literature argues that more women models would increase female enrolments, is potentially relevant to critical mass. The presence of visible, tenured women in significant numbers contributes (or otherwise) to the ascription of maleness or of sex neutrality to a discipline. Hence, we have collected data about women staff for each survey discipline in each of the ten institutions in the policy review strand as part of the construction of "discipline profiles", as well as student data. The issue of image is a central factor in institutional ecology (image of institution, of different disciplines and of peer groups). There is no immediate evidence that it is relevant to critical mass, but it is central to the question of labelling or perception of disciplines as male, female or sexneutral. And so on.

Questions have been included in the questionnaire to students in the longitudinal study, designed to draw out evidence of the potential influence (or relevance) of each of the ten factors. The structured interview schedule for the survey of women scientists has similarly been designed to seek material on each of the ten factors which would enlighten us on how the interviewees *overcame* the barriers. In the policy review strand, the ten factors have been raised in group interviews with Deans and Heads of Schools, careers staff, etc, with the help of brief research-based discussion papers. Future research reports will discuss the meshing of our several levels of data and our conclusions. Here we touch briefly only on critical mass and on institutional ecology.

Critical Mass

This is the threshold beyond which a minority group needs to move, in order to establish (a) a sense of normality, a transcendence of identity beyond "the rubric of exceptions", and (b) sufficient support to the minority group for its members to continue, not drop out and to achieve without constraint. Alma Lantz describes this as a process under which "once a certain proportion or number (mass) of a population is present, recruitment and retention of that population *becomes a selfsustaining and self-perpetuating system*" (our emphasis) (Lantz, 1982). Critical mass theory postulates that there is a minimal level, or cut-off point, above which change occurs, which is causally related to the *proportion* that the "critical mass" is of the whole. The theory is one of level of influence, of identity, of potency as a change agent, and not one of numbers. The threshold for change (even if the change is from the perceived abnormal to the perceived normal) may well vary from scheme to scheme, issue to issue. Lantz postulated that for success (ie self-sustaining and self-perpetuating), the effect of the passing over a threshold into normality (away from untypicality) had to be *evident*, or felt in the relevant community.

In designing the theoretical framework for WISTA, we have moved beyond the idea of a single threshold to examine *three thresholds on a continuum*. In addition to the cut-off point between the perceived "sexnormality" of an undergraduate discipline (or indeed "sexneutrality"; not the same thing), we hypothesise a shift (upwards) from low enrolments at the level of the "rubric of exceptions" (mining, metallurgy, surveying with female enrolments below 8%) to "abnormal" (chemical engineering, physics, around 15%) to "untypical" (computer science at 26% or so) to "sexnormal" for women (chemistry with 45% or so), and are examining this in the context of a major statistical analysis of about twenty disciplines across ten institutions. This also involves a conceptual look at the image of each which will be crossrelated with the discipline's statistical female profile at all levels.

Ecology of Institutions and Scientific Disciplines

Educational institutions are complex organisations, and the use of ecological analogies is one way of helping to explain their particular form of reality of influence. The principal analogy is of an ecosystem in which organisms adapt to their setting and are found in "ecological niches".

Stern's work in the USA has provided a useful basis for elaboration in the WISTA project. Stern's theory postulates a Needs-Press model in which needs refer to the psychological needs of individuals and press refers to the external situation which influences these. Stern's study of some 1076 students at 32 colleges and universities during the 1960's, looked at "needs" in terms of student achievement orientation and dependency while the college environment was described in terms of its intellectual or nonintellectual climate. Stern's data are analysed in the context of his explicit concept of "the college as an ecological niche" (our emphasis). Stern's taxonomy distinguished type of institutions by discipline status and/or ethos; that is, independent liberal arts, engineering, teacher training, business administration, university-affiliated liberal arts and denominational. The WISTA approach, however, sees the ecological niche as operating at the level of Departments or Schools and not in the college or university as a whole. Stern himself developed his concept to describe the six types of schools as an ecological niche for different kinds of students. Thus, engineering schools were seen as concerned with achievement orientation and aggressiveness, with independence and thrill seeking, while liberal arts were seen as concerned with intellectuality and autonomy. Business administration was seen as instrumental and anti-intellectual, while Stern categorises the denominational as more purposive and goal-oriented than larger universities. The WISTA team see the question of both the perceived status and the actual status of institutions as an essential element of the institutional ecology, and the project therefore takes account of three designations of status which carry relevant implications of ethos or image :-

Older Universities	: with a balance of liberal to scientific Faculties, that is, widely seen as "traditional" and suitable for women;
Newer or Technological Universities	: former Institutes of Technology or Technological Colleges having acquired university status, with a predominance of Faculties and Schools which historically have recruited few women and seen as "non-traditional".

Institutes of Technology : former Technical Colleges or Institutes which have developed from the outset as centres of technical and technological education with very few disciplines which have historically proved attractive to women, and seen as "non-traditional".

One important context for these subdivisions is the perception of students (or, in the case of school-leavers, of their parents) of the status and ethos of the institution. The researchers, however, also agree with Astin's (1968) view that educational environment is as much what other individuals actually do to us in the interactive process, as what we ourselves believe or feel. Thus we see this angle as one both of image and of marketing.

Bio-ecological analysis can be conducted at three levels : individual, population and community. Hannan and Freeman (1977) argue that in organisation ecology, analysis is needed at five levels : members, subunits, individual organisations, populations or organisations and communities of (populations of) organisations, the last three of which they discuss as general ecology. In the WISTA project, we see the structured organisation of the different sciences and faculties, the ways in which mentorship operates, and the normative assumption that male behaviour patterns are the cultural norm, as examples of elements of institutional ecology in Hannan and Freeman's terms. We have also drawn on Hannan and Freeman's theory of the population ecology of organisations for part of our theoretical framework. Among a wide variety of ecological perspectives, most appear to focus on selection perspectives - attributing patterns in nature to the action of selection processes. An alternative perspective from organisation theory is the adaptation perspective under which subgroups in an organisation (managers or dominant groups) "scan the relevant environment for opportunities and threats, formulate strategic responses and adjust organisational structure accordingly" (Hannan and Freeman, 1977).

Wakeford (1984) examined 25 British and Irish Medical Schools in the context of student perceptions of their learning environments, using a taxonomy of eleven dimensions ranging from educational facilitativeness, student involvement in decisions on the curriculum to ethics and concepts. Several of Wakeford's dimensions used to "measure" the Schools are broadly relevant to the WISTA project, but we have refined them further in the context of our ten factors :-

Wakeford's dimension	WISTA dimension
Concepts versus detail	Attitude to science (girls allegedly are more attracted to theoretical and interest-based science than its detailed application in applied science or technology).

Educational facilitativeness	Male territoriality excluding girls from computer use or from hands-on scientific experimentation. Teachers and lecturers facilitating girls' access to scientific experience if they lack previous hands-on experience.
Enjoyability. Vocational versus scientific orientation	Girls' alleged choice of maths and science through liking and interest, boys' alleged choices for vocational reasons.
Ethical teaching emphasis	Girls' alleged rejection of sciences seen as socially irresponsible and destructive, and alleged attraction to those sciences seen as caring, curative and responsible.
Friendliness	Peer pressure, male hostility; or male and female supportiveness to "untypical" female choices.

The question of the structural nature of disciplines and the potential influence of knowledge-packed as distinct from experience-based teaching and learning, was investigated further by a research team in a Dutch university. Gaff, Crombag and Chang (1976) looked at Departments of Chemistry, Medicine, Law and Psychology, using an inventory of 135 items reduced by cluster analysis to ten scales, ranging from the differences (of higher education) from secondary school and the description of discipline in the programme, to the extent to which students' interests could be met and the relevance of subject matter. The discipline differences recorded by the Dutch team, confirm the view of the WISTA researchers in designing this project that the image, structure and content of disciplines as constructed by different higher education Departments or institutions, is a key explanatory factor. In this Dutch study, for example, chemistry as a discipline was perceived as pressure-packed and heavily prescribed (ie little room for student choice or for differing student interests). Medicine was seen as memory-oriented and highly structured, psychology as freewheeling with an independence of atmosphere.

And indeed, the WISTA design presupposes an integrated review of our data from all three strands, at the level of each discipline.

Focus on discipline differences

One major focus of the enquiry is why some disciplines continue to recruit better than others, and why the same discipline either recruits very differently in different institutions, or succeeds or fails in attracting or keeping women postgraduates. That is, we move from the science : non science debate to examining interdiscipline differences. While image and marketing are clearly relevant in the establishment of a discipline as perceivedly strong, relevant, topical etc, the influence of the University or the Department on the marketing, image, and structure of individual disciplines and of female progression in them, remains central.

The following disciplines were selected as those which would form the basis for selection of student sampling in the longitudinal study, the basis for selecting the sample in the working women scientists study and the basis both for collecting student and staff statistics and for discussion with academic staff, in the ten higher education institutions in the policy review strand. **Group A**:- Foundation subjects in science and technology which are both a discipline for study in their own right, and a service subject or prerequisite for degrees in science, applied science or technological disciplines like engineering or mining - that is, mathematics, physics, chemistry (all strands), biology (longitudinal study). **Group B** :- Disciplines which are clearly non-traditional and which recruit well below the 30 per cent cut-off proportion of female enrolment (maths, physics and chemistry also partly qualify under this criterion), that is, geology, geophysics, mining, all branches of engineering, metallurgy, surveying and cartography, building surveying. **Group C** :- Other disciplines seen as important in the economic or political future development of science and technology, that is, microbiology and biochemistry, biotechnology, genetics, food technology. We will construct discipline profiles in the context of their place in an ecological model of behaviour.

One factor of institutional ecology is the male:female balance of the student enrolments in the institutions as a whole. If three out of four students on campus are male, one can hypothesise that this affects the image of an institution, the "fit" of women students to their ecologically new environment, and their adaptability to what Bourdieu calls the dominant ideology in higher education.

The statistical data for 1985 shows that there are sharp differences not only between our three categories of institutional ethos but also within the apparently homogeneous category of traditional universities, even in the overall male:female balance.

	Women as percentage of		
Examples of	All Students	Masters by Research	Ph.D.
A. Traditional Universities			
University of Queensland	48	26	27
University of Western Australia	44	40	25
University of Adelaide	42	35	30
B. Technological Universities			
University of New South Wales	36	30	26

C. Institutes of Technology

Western Australian I.T.	43	27	-
South Australian I.T.	35	14	-
New South Wales I.T.	28	26	-

This is clearly part of overall ecology; and also must influence institutional image. Similar interinstitutional differences operate when we look further at discipline profiles.

Our early hypotheses about the complex differences between different disciplines (chemistry vs. physics, chemistry vs. microbiology) or sub-disciplines (civil engineering vs. chemical or materials engineering) are confirmed so far by the preliminary analysis of 1985 statistics from the ten institutions. We see these as related to image, to attitudes, to critical mass. When we look at the discipline-level statistics, moreover, differences emerge which will need explanations in terms of such factors as mentorship, the structure of disciplines as well as their image, their perception by students as vocationally-oriented or "interest-based", and the nature of careers advice. At undergraduate level, chemistry recruits at over 30% female in three institutions and at over 40% female in a further four, thus qualifying as either "suitable for women" or "sexneutral" in terms of WISTA definitions of nontraditional, traditional or sexneutral. Physics by contrast, recruits at the level of only about one fifth female in almost all. Biochemistry and microbiology recruit from second year and average about 60% females in five institutions, higher in two and over 50% in the remainder. Yet when we look at the female postgraduate enrolments in Masters by course-work, by research and in Ph.Ds for these, we find that the chemistry female figures drop to the level of physics and other "male" undergraduate subjects; but in biochemistry women students are in a substantial majority in most institutions (71%, 47% and 40% of Ph.D.s, for example, against a general Australian female average Ph.D. achievement of 27%). Only in one institution does biochemistry not have more than 9% women Ph.Ds - they are all at Masters level (100% of Masters by research). These patterns raise questions. Is the last institution with few female Ph.D. Biochemists but many at Masters level, using a sexist mentor system? What attracts women to pursue biochemistry but not chemistry? Why does a secure undergraduate "critical mass" in chemistry, become an untypical minority at postgraduate level?

Conclusion

This is essentially an introductory paper. Finite conclusions cannot be drawn until we set the analyses from the three strands together and "mesh" the results against the sets of hypotheses which we originally constructed. The policy review strand is entering its final phase, the longitudinal study is in its second year of three (or perhaps four) and the women scientists study is nearing conclusion. A first WISTA progress research report will be completed in 1987 for publication.

Meanwhile, preliminary analyses of the statistical and interview data, the issues raised by Deans and Heads of Schools at group meetings and the issues raised in responses to the discussion papers circulated on the ten key factors, lead us to some preliminary observations on the relative ranking of the factors. For example, although same sex role models may well continue to be an issue in terms of breaking the stereotype, the WISTA evidence so far places even further into question the belief that they are influential as a policy mechanism. That is, the evidence so far does not support the widely held belief that presence of women staff as such is actually correlated with increased female enrolments. On the other hand, it is seeming more and more likely that high profile and visible women may affect the imaging and marketing of disciplines as less overtly masculine. The complex issues of image and marketing emerge as more influential, and preliminary work also suggests that the mentor role is under-estimated both by institutions and by researchers. Male attitudes towards women achieving in "male" sciences remains a key factor : but peer female attitudes towards female achievement begins to emerge as an underestimated issue.

The next phase of WISTA analysis will work on clustering factors which the longitudinal student data, the working women scientists study and the policy review strand, suggest are influential in combination rather than as such.

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"The Elephant is still Alive".

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Abstract

When considering women's research in the field of women and technology, it is evident that two separate groups of women take an interest in this research.

One group are the sociologists, the psychologists, women from the social sciences and humanities. Another group are the technicians, the engineers, the scientists, women from the natural and technical sciences. Often conflicts exist between the two groups of women, conflicts which in many cases are not brought into the open.

In my paper I shall try to describe the conflicts as I see them, analyse the possible reasons for conflicts and outline ways of overcoming the conflicts, in order to further cooperation and take fully advantage of the diversity of knowledge among the women involved.

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Introduction

The following paper is by no means a report on a research project, with questionnaires, interviews or statistics. It is based solely on personal reflections on experiences during 5 years in the research field of women and technology. You will therefore not find any notes or references at the end of the paper. My main reason for writing this paper is to structure and clairfy my own thoughts but of course it is my hope that others may gain a bit of insight and understanding as well, or may be provoced to discuss the points of view expressed.

My educational background is a M.Sc. in Electronics Engineering from 1971. When I first realized, in 1982, that women's research in technology was taking place, I was puzzled by the question: "what would be a feminist technology?" and therefore started participating in seminars, conferences etc. to find an answer to the question.

In the first seminars I quickly realized that I was one of very few women technologists, the other participants being sociologists, psychologists and the like. Consequently, discussions were totally dominated by social scientists. And I felt awfully [illegible] alienated to the language used, overlooked and redundant in the gatherings. Now, instead of giving up the interest, I became aggressive and pushed on, asking lots of questions to be able to understand the language of social science, and trying to make myself and my technical background visible, understandable and relevant to the social scientists.

These feelings and experiences of women technologists among social scientists, I have seen ever so often since. At the second nordic conference on women, science and technology, University of Aalborg, August 1985), professor in sociology, Hilary Rose, brought up the conflict

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in a very humorous way, talking about "the Elephant in the room" - the conflict, which everybody is aware of and which nobody wants to speak openly about. Speaking openly about it, is exactly what I intend to do in this paper.

The groups....

Since women's research originally emanate from the social sciences and the humanities, it is no wonder that women's research in the natural sciences and technology was first taken up by women researchers from the social sciences and humanities. Their knowledge in the field of science and technology is based mainly upon theoretical studies, observations and analysis, and they may themselves feel alienated towards and threatened by science and technology.

Later on women scientists and technologists have taken an interest in the research on women and technology. Basis for their knowledge is a mixture of own experiences during study and during work and a lot of non-adapted and unstructured feelings from events in their daily life.

When discussions often tend to be dominated by researchers from the social sciences and humanities it can be explained partly by different backgrounds, partly by different research traditions.

The social scientists often come from research institutions with a long tradition for using the language - written as well as spoken - as "research instrument".

The technologists only seldom have this background in research institutions, many of them are working in industry or they are working with technical problems and not with questions of women and technology. And even if working in research institutions, research tradition in science and technology is not so much based upon the use of the language,

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as it is upon facts and figures.

In other words, a negative result of the socialisation taking place in technical and scientific educations is that the women (and the men!) technologists lack a language and a framework for reflections, discussions and analysis of their own situation and the job contents.

...the conflicts...

The early research, carried out by social scientists, was mainly concentrating on women as users of technology, ex. office automation technology, perinatal technology etc.

Since research is not objective - the questions asked, the hypothesis put forward and even the answers found are influenced by the researchers own feelings, experiences and values - research results were often depressing, pointing out all the negative aspects of the use of technology, often giving rise to attitudes of strong rejection of technology.

Clearly, such attitudes of rejection could not be totally shared by technologists, who themselves have taken an interest in technology and are working with it every day.

Thus, here is the first conflict! The fundamental view of technology differs! The sociologists tend to see the negative aspects of the use of technology, seeing it as a threat towards individuals as well as towards mankind. They therefore want to limit the use of technology to an absolute minimum. On the other hand the technologists tend to look upon technology as a tool, which - when correctly applied - could be brought to good and efficient use in improving living conditions for all.

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The second conflict, that I want to mention here, is evolving around the research on women's attitudes towards engineering educations.

With a growing interest in recruiting girls to technical educations and jobs, such research has been initiated by government and carried out by sociologists. Focus has been on feelings, impressions and experiences of the few women engineering students, and results emphasize a dualistic differentiation between the feminine values of the women and the dominating masculine values in the educations and the surroundings.

When presenting results of this type to women engineers, reaction will often be hostile. The engineers protest against being turned into "research objects" and they do not acknowledge the existence of such negative experiences as for themselves.

The first point of protest can again be explained by different research traditions. In technical and scientific research a main tenet is the objectivity of research ie. that it is possible to separate object from subject. The researcher then can observe the object without interfering or being part of the observed.

In women's research - even if not in all social research - this separation between subject and object does not exist and is not wanted. In one of the often used research methods, the qualitative in-depth interview, the situation is that the interviewer will try her very best to put herself in the situation and in the place of the interviewed, thus interfering with and taking an active part in the research proces.

Now, the female engineer protests, because she feels like an insect being put under microscope and analysed, part by part. This is the way she herself might conduct research, being unfamiliar with the subject-subject research methods of the sociologists.

The protest against the negative findings in the research and the dualistic split between feminine and masculine values can be explained in several ways. One very simple explanation may be that human beings tend to forget bad experiences and remember only the good ones. Another explanation may be that - due to a strongly developed selfesteem - the women engineers protest against the whole idea of individuals being turned into members of a group - the group of women engineers with whatever similarities they may have. Yet another explanation is that during many years in male dominated surroundings they have more or less adapted to masculine values themselves, or rather, they have developed their masculine qualities more than the average woman. Finally, accepting the existence of a dualistic split between own feminine values and masculine values dominating in their surroundings, certainly would give a lot of problems in their daily, working lives, therefore this split is better not acknowledged - if it does exist at all?

- - and the solutions?

So far I have tried to call forward the Elephant, to confront it and to explain, why it is here with us in our field of research. Now remains the question of how we can turn our Elephant into a "work horse", to fully utilize the enormous power of the Elephant, or in other words, how can we take advantage of the richness of diversity among the women involved in the research.

To do this we must build brigdes. One brigde that must be build is between science and technology on the one side and social sciences and humanities on the other side. Women technologists should learn from the social scientists a language enabling us to critically reflect upon, analyse, understand and discuss our situation and our job.
A broader concept of technology, including elements from social science and humanities, should be defined.

Another brigde to be build connects femininity and masculinity. These concepts should not be defined as mutually excluding each other and in opposition to each other, since such a definition will only reinforce sex stereotypes, which have little - if any - relevance to real women's and men's lives. Instead feminine as well as masculine values and qualities should be seen on the same broad scale as possibly belonging to both sexes, depending upon upbringing and personal characteristics, not upon biological sex.

With a more holistic definition of femininity and masculinity it will become evident that feminine values already are present in technical and scientific research, educations and surroundings. Due to a hierachization of values in society, giving higher priority to masculine values, clearly connected as they are with power and influence, the feminine values in science and technology have been made invisible, in the presentation of results. It is one of our jobs to upgrade and make visible the feminine values in science and technology.

In my view one large step towards the brigdebuilding was made on the European conference Women Challenge Technology, Elsinore, Denmark, November 1986. Here technologists and social scientists came to a common recognition of the necessity of etablishing new fields of knowledge, across traditional scientific barriers. Also the need for discussing and exchanging views of interscientific concepts of technology, of femininity/masculinity and of scientific research methods was generally accepted and agreed upon.

Let me end this paper by expressing the hope that GASAT IV - A Celebration of Diversity - will take us all some steps further on this difficult road.

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WOMEN IN SCIENCE IN AUSTRALIA: THE SECOND STAGE.

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SUMMARY

This paper describes the chronological development of action taken to remedy the under-participation, and underachievement of women and girls in science in Australia. It identifies those features of this development which have led to an apparently slow rate of progress on the resolution of the problem, and presents suggestions for an alternative approach or "second stage". It argues that in order to bring about a significant change a more co-ordinated approach, involving a broader action front must be adopted. In particular, sympathetic men, industry, academia and parents must become more involved. Finally, it intimates that lasting changes will only result when institutions and the nature of power itself become the main focus of the attack.

INTRODUCTION

The issue of the under-participation and under-achievement of women and girls in science in Australia is now firmly on the public agenda. It features regularly in the media and television documentaries on the subject are shown in prime viewing time. State and Federal governments, professional associations and industry are all involved in discussions on the topic and projects are run on budgets which are large by Australian standards. Yet, whether all this activity will have a marked and lasting effect upon the current situation is open to conjecture. Unless results become more demonstrable, Australia could be about to witness the beginning of the end of the issue, as one to which resources and time are committed, rather than merely the end of the beginning of the first stage of its resolution.

To prevent this, activists in Australia, may need to take a leaf out of Betty Friedan's book[1] and invoke a "second stage" of attack. This would include involving men more, fighting on a broader front, and adopting a more co-ordinated approach. If this is not done, then this struggle will suffer the fate of many movements, including previous women's protest movements, and disappear into the annals of history with little trace.

Additional points to those raised here have been detailed by Yates[2] and the reader is referred to her paper for further discussion.

GIRLS IN SCIENCE

The problem of girls'(or young women's) performance and involvement in science and mathematics was first highlighted in Australia in the mid 70's, as a result of two Federal Government sponsored reports.[3,4]

The reaction to these publications was a hive of activity, in the form of projects, aimed at eradicating overt and covert discrimination against girls in schools. These projects were funded almost entirely by the Commonwealth Government. Unfortunately, most of them were small "one off" ventures. They occurred in isolation from each other and there was little or no co-ordination or co-operation between them.

Initially, the focus was upon young women in the final two years of high school, and specifically, upon girls and mathematics. Attempts were made to influence female students' choice of subjects, higher education courses and career patterns. Later on, younger girls, those in years 9 and 10, were targeted, as were teachers. Regretably, parents were involved to an almost negligible extent.

Shortly afterwards, the focus widened again, this time to include trade and apprenticeship training as well as preparation for the professions. "Girls in Trades Days" and "Expanding Your Horizons" conferences were a common feature of this period.

There were problems however. Students did not like being told what to do and think; projects met with resistance from teachers and there was an absence of a large scale awareness of the importance of the issue or a commitment to its resolution. The end result was that work on the problem was left to a few highly committed individuals scattered throughout Australia. Unfortunately, large distances precluded regular personal contact between them and there was an absence of a formal communication network. This meant that in many cases, re-invention of the wheel occurred, as people in one State or even in different parts of the same State beavered away in ignorance of each other's work.

During the late 70's, the hub of activity shifted from these highly committed individuals, to State education authority initiatives. State

Equal Opportunity Units were established, which produced propaganda material such as videos, audio tapes, slide sets, posters, brochures and newsletters. In addition, Unit staff spoke at, or provided, a consultancy service for teacher workshops on the issue. All of this gave teachers much needed support and helped raise awareness of the problem. Yet the number of teachers involved remained small.

By the early 80's other changes in emphasis and direction had occurred. The most significant of which, was that girls and science had emerged as an issue in its own right and was no longer subsumed under mathematics. By this time also, much more was known, largely from British and American studies, about the factors affecting girls' attitudes towards and perceptions of science, as well as more effective means of altering teacher behaviour. Practices, materials and activities were therefore altered to incorporate these new findings.

In particular science itself was targeted. It was no longer seen as gender or value free and the terms "gender inclusiveness" or "girl friendly" became the mode. This period also saw the beginning of two major Federal Government funded projects, GAMAST and WISTA, which are currently underway. The former is an acronym for the Girls and Maths and Science Teaching Project, which is designed to alter the participation of girls in mathematics and science in primary and early secondary schooling by altering teacher practice. The latter, Women into Science and Technology, is more traditional, in that it focuses upon the collection of data on those female students in higher education who choose to study science.

The 80's also heralded the publication of major policy documents on girls' education[5,6] and girls in science[7], the formation of a grass roots, science teacher network (Mc Clintock Collective), and the increased involvement of professional associations and industry.

WOMEN IN SCIENCE

Up until the late 70's, the focus of attention, in relation to gender and science, had been exclusively upon the school system. The perspective widened, during the mid to late 70's, to include the employment sector, largely as a result of the requirements of anti-discrimination and equal opportunity legislation introduced during this period. Essentially, this new activity took the form of data gathering on women employees to produce staffing profiles and a review of recruitment and promotion practices.

The first study to highlight the situation of women scientists was an investigation into the state and status of women in the government scientific organisation CSIRO (Commonwealth Scientific and Industrial Research Organisation). This body is one of the major employers of Australia's scientists and mathematicians especially those holding doctorates, and is responsible for the bulk of applied research occurring in Australia.

The report of this study graphically documented the plight of the women scientists and produced statistical data on their limited recruitment and retarded promotion. In addition, researchers were able to pinpoint management practices which were discriminatory[8].

Similar investigations, carried out in the higher education sector, showed that women scientists didn't do very well there either[8-13].

Little has been published so far, about women scientists and mathematicians in industry but it is unlikely that their situation would be any different to that in academia or CSIRO.

It is little wonder then, that the late 70's, early 80's, saw the emergence of feminist networks designed to raise the profile of women in science. Amongst the largest, are WISENET (Women in Science Enquiry Network), WIE (Women in Engineering) and WINC (Women in Chemistry Network). WISENET is centred close to the Federal Government in Canberra. WISENET acts as a clearing house and information exchange via its newsletter and has recently obtained a grant to produce a directory of women scientists in Australia. WIE and WINC are discipline based and both are housed in Melbourne. They provide speakers, distribute a newsletter and run meetings for their members on topics not covered by their parent professional associations, the Institute of Engineers and the Royal Australian Chemical Institute, respectively.

The findings of the report into CSIRO, mentioned previously, prompted this organisation to become more proactive in the field of women and girls in science. Their largest commitment to date, has been the "Women in Science" project. This consists of a video showing women scientists at work; giving female scientists employed by CSIRO time release from work to speak to schools; and encouraging female school and university students to spend time with these women at their workplace in order to have a greater appreciation of what scientists do.

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THE END RESULT

How effective has all this burgeoning activity been? According to recent reports[5,6,14], the answer seems to be, not very effective. The workforce still shows a marked degree of sex segregation. In 1986, women comprised 39.3% of the labour force, however 63.5 % of these were to be found concentrated in only three occupational groups; clerical, sales, and service. Women comprised almost 50% of those in the Professional and Technical group, however 35.8% of these were teachers and 31.3% nurses. In addition, women earned only 82% of the average full time ordinary earnings[15]. In Victoria, Australia's second most populous state, in 1986, women still didn't hold many senior positions in education, major companies or government instrumentalities, and made up only 16.5 % of the State's administrators, managers or executives[16]. Women it appears, marry later, have fewer children and have them later than they did a decade ago but their training for work is still too narrow and their chances of finding good jobs have barely improved[16].

Yet, as late as 1987, the bulk of attention and most of the energy still remains directed towards the school system, and even here the results are minimal. From 1975 to 1985, female students outnumbered male students in the final years of secondary schooling in Victoria. Yet they currently make up fewer than 1 in 10 apprentices, and most of these are hairdressers, only slightly more than a third of technical and further education students and less than 50% of those enrolled in colleges and universities[16]. At school, female students still shy away from, and under perform in, the mathematics and the sciences; in higher education they choose to study arts, medicine or law in preference to engineering. They dominate teacher education institutions yet they are sparse amongst doctoral candidates[9].

CONTRIBUTING FACTORS

What are the possible reasons for this apparently slow rate of progress? One could be the origin of the reform movement. In Australia, the initial impetus for work in the area of girls and science did not come from industrialists' fear of a lack of suitably qualified scientists or engineers, but rather from feminists and left wing radicals, many of whom were teachers and active supporters of the

Australian Labor Party. As a consequence of this, amongst the main power groups, the movement has lacked credibility, its proponents being dismissed as the "radical fringe".

Its roots in feminism has also helped keep it, like other women's issues such as health and childcare, on the margins, while male issues such as the economy and defense have achieved greater prominence. Furthermore, the particular brand of feminism involved, that of the 70's, was, by and large, anti-male. This has led to the exclusion, if not the alienation, of men from any part in the reform movement. Added to all of this should be rivalry, petty jealousy and an unwillingness to part with ownership of the issue amongst workers in the area, and a clearer picture of the reasons behind the slow progress becomes apparent.

Compounding these problems has been the vexed question of a lack of a suitable theoretical base on which to build the reform movement. Such a base should provide both a rationale for change and a guide as to the direction such change should take.

In the early 70's, advocates of reform saw the problem as yet another example of women's oppression and powerlessness. These people argued for change on the basis of equity and justice, and lobbied governments under the banner of "equal opportunity". A slogan which has steered Australia's education thinking ever since the Karmel Report[17], of 1973. Equal opportunity was initially interpreted as equalising resources for girls, or making up in some way for deficiencies in their background or abilities[2]. As Yates[2] has pointed out, this approach was problematic, in that it tended to "blame the victim", or tried to persuade girls to do what boys were doing, and left girls "always a step behind trying to catch up". The more recent move towards "gender inclusiveness" may go a long way to providing a firmer, less negative framework for change, and merits further analysis.

Throughout the evolution of action in the area of women and girls in science, in Australia, has been a preoccupation with the school system. This is symptomatic of a guiding philosophy of social change which believes that one can change society simply by changing schools. A comprehensive critique of the limitations of this approach in regard to programs, in the area of girls in science, has recently been published by Kelly[18], and readers are referred to her paper for detailed discussion.

Yet another feature which has compounded the problem of a lack of significant progress has been, that whilst there has been considerable rhetoric with respect to a shortfall of scientists, technologists and engineers in Australia[19,20], the job market and government funding policies have yet to provide evidence of the same. Students are understandably reluctant to enter these professions unless chances of employment become guaranteed.

Even if a massive change in school students' attitudes towards technological careers were to occur, any gains in secondary schooling may well be negated when these students undertake further studies or enter the workforce.

At the present time, the tertiary sector has largely ignored the issue of women in science, preferring to believe that there is little they can do to alter attitudes formed in schools. Tertiary educators remain unconvinced of their role in, and resonsibilities for, the formation of positive attitudes towards a discipline, for encouraging the pursuit of higher degree studies, or for counselling career aspirations with their women students. Like the industrial sector, they feel content in the belief that they are contributing to alleviating the problem, in so far as they have attempted to remove formal barriers and discriminatory practices. The rest is left to the individual.

There are two exceptions to this trend. One is a project on Women in Engineering based in selected tertiary institutions in various States. This exercise is designed to encourage more women to enter and complete studies in engineering. Another is couched in a chemistry curriculum development framework[21].

The industrial sector has also made only limited moves in regard to admitting a need for positive action in the area of women in science. Whilst acutely aware of a dearth of suitable women applicants for job or promotion vacancies, industry has tended to allocate blame outside its boundaries and pushes responsibility for change to governments or women themselves.

THE WAY AHEAD

There is always a danger when work is frenetic to confuse activity with action. By focussing almost exclusively on one sector and carrying out most projects at grass roots level, Australia has failed to analyse the direction of, and rationale for, change, or to evaluate the effectiveness of the strategies employed. This needs urgent remedying.

Suggestions are now given for how the "second stage", alluded to earlier, might be approached.

The problem should be tackled on as wide a front as possible. The workplace and higher education institutions should be made to recognise their responsibilities toward the issue of women and science and implement programs for change. Parents, as well as teachers, should become the focus of initiatives at the school level.

Above all more men need to become involved. Sympathetic men in academia, in research, in professional associations, in industry and on influential committees need to be cultivated and encouraged to work on this issue.

The problem also needs to be addressed in a more coherent, concerted and co-ordinated fashion.

A national Task Force on Women in Science, should be established to oversee activity in the area, to co-ordinate action and to monitor progress.

All new Government funded projects should be subjected to close scrutiny to see how they link together or build upon existing work in the area. They should have in their proposals, mechanisms for evaluation, critical analysis and dissemination of findings.

Regular reports as to results or progress (good and bad) should be mandatory.

Specifically, this Task Force, should prevent duplication or wasted effort and try to match rhetoric with reality. As a first step, the Task Force should organise an Australian GASAT to bring workers from all sectors together, to share their experiences.

All of the action described above, would mark the beginning of the first to the second stage of Australia's response to the problems of women and girls in science. Even this may not be enough. Ultimately, it may prove necessary to, as Friedan has predicted, "transcend the battle for equal power in institutions to (concentrate upon) the restructuring of institutions and the transformation of the nature of power itself"[1].

This latter task may prove to be the most difficult of all to achieve, and will certainly not occur in the short term. Yet it must be recognised that it is both a necessary, and ultimate, goal, in order to secure both a lasting and a meaningful change in the situation facing women and girls in science, in Australia.

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WOMEN AND TECHNOLOGY -

Strategies for change in male-dominatet areas of education and training - from a feminist point of view.

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Summary:
In Denmark women have one of the worlds highest frequency-rates of participation in the labour market force. And formally we have got equality between women and men, but in reality there is not equality neither in the productive nor in the reproductive area. One reason has to do with the sex-segration of the educational- and the labour market system at the structural level. In order to counteract this strong segregation wich favours men, we find that one powerful strategy is - paradoxicaly enough - is to develop women-only courses in the field of technology, instead of the usual male-dominated co-educational ones.

This paper is concerned about two such courses, implemented in two different systems:

- an inservice university for teachers
- a training-center for skilled and unskilled workers in blue collar jobs.

In order to implement such courses in male dominated areas, you have to overcome a lot of barriers - both hidden and open.Our experiences are that NETWORKING - where women support women, is both a necessary and and a strong offensive strategy in this contex.

Women and Technology- strategies for change in male dominated areas of education and training-from a feminist point of view.

Often the Scandinavian countries are singled out as countries wich have got real equality between women and men.
Unfortunately this is not true. But formally women have obtained equal opportunities for education and jobs.

During the boom in the sixties, when in reality there was a shortage of workers, both women and "other minorities" could be used on the labourmarket. In those years we felt that women were on the right track-despite the fact that often they alone had to carry the heavy burdens connected with the new development.

Today Denmark is one of the countries with the highest frequency of employed women. So why should we pay particular attention to girls/women? Will there not automatically in the Danish education- and labourmarket system be shown consideration for girls/women, and will not gradually more and more women be recruited into all professions and at all levels?

Unfortunately the high frequency of employment for women has not solved women's problems. A number of other factors are obvious.
Insufficient child-care possibilities, unequal division of labour in the family, and in the labour market both horizontally and vertically, women's inadequate salaries, and their lack of participation in and influence on important political decisions have altogether made sure that real equality has not been realized.
Add to this that cutbacks, tightening abolitions and social reductions have hit women especially hard, and that unemployment prognosis for the 90's are alarming. But of course prognosis are projections of tendencie trends, and therefore political power and will are necessary to make sure,

that they do not become self- fulfilling prophecies.

This presupposes that at all levels we must work for changes and measures, which do not further contribute to the marginalization of women, but which - on the contrary - strengthen and improve their position, and give the possibility of greater influence.
One level where innovations can be made in favour of women is in the state/public education system, which is not directly subject to the "free" market powers, and which is therefore easier to influence politically.

What we want is to describe two different educational/training institutions and how-with our basis in the new women's movement- we have helped to overcome opposition inside these and develop new courses.

In short we wish to present two women-only projects, which have been developed and carried into practise within the following framework.

1. The Specialarbejderskolen in Århus, a training centre for skilled and unskilled workers, mostly working in industry, and
2. The Danish School of Educational Studies, department of Århus, an in-service university for teachers. (SES)

We were both originators of the two women's projects, and have since then been projectleader and teacher respectivily at each course.
We have both had to face a lot of opposition, hidden and open, but helped by our "network" we have been able to brake down a number of barriers and in collaboration with the women- participants made visible some otherwise tabooed or neglected problems.
But before telling about our experiences in developing the courses, we wish to ekspress, why we find women-only-projects so important especially in the area of natural sciences and technology.

A Women-only-project is to give women voice.

I The main goals/reasons are:
To qualify women for more possibilities so they can make wider educational or occupational choices than they/we traditionally do.
For teachers especially it is important to become capable of teaching subjects which women do not teach-traditionally because of their identification models for girls at school.

II That women through the training or learning process in a traditionally male area get the opportunity to experience a course, which is without male dominance, and wich

- builds on women's own experiences and qualifications
- aims at women acquiring this new knowledge without experiencing feelings of inadequacy, fear of technology, and pressures for achievement and competition.
- tries to build up networks where women can strengthen their possibilities of becoming subjects of their own lives.
- gives women the opportunity to develop a professional identity, i.e. familiarity within a new sphere.
- helps to gain selfconfidence and motivation to work, study or teach inside that particular profession, and prepares women to resist the negative expectations, they may be exposed to from workmates, colleagues or from society as a whole.

III That in society it is necessary that technical-scientific subjects are given criticism and an ethic, which contains new and necessary dimensions based on humanistic and female values.
We wish to give women the opportunity to gather and to develop their skills and knowledge, hoping it will promote their possibility of becoming influential. We wish to give women voice.

The women-only course for teachers

The Royal Danish School of Educational Studies is an institution where teachers, who teach in the "folkeskole", compulsory public comprehensive school, can get in-service training courses, study pedagogy and psychology, school subjects, and matters concerning school development.

At the department of Århus there have for a number of years been both research projects and courses on gender-role aspects and especially on the socialization of girls at school.
This research and teaching has been generally recognized and appreciated. Like research in other western countries it has pointed out the unequal conditions of girls and boys, women and men at school - and in the rest of the danish educational system.
At the (S.E.S.) School of Educational Studies, problems and oppositions between men and women started, when the institution had to consider

the fact that we were some women, researchers and teachers, who in our various positions made concrete demands and developed propositions for teaching strategies, which could help to eliminate in equality and the marginal position of girls and women especially in the field of information technology. At the SES the fight was about whether women-only courses were to be introduced into traditionally male subjects- or not.
It should be mentioned that in the danish "folkeskole" we have a long and "proud" tradition for co-education at all levels.

For example already in 1903 it became statutory (inspired by the US) to gradually make all schools free mixed-sex CO-educational schools. So taking "affirmative action" for women as a strategy in connection with the development of courses at the SES branch in Århus was until the schoolyear 84/85 completely unheard of, and it was met with resistance especially from men, who regarded it as grossly discriminating. The teaching policy of the SES is made out by the ruling democratically elected organs. Annually it is decided by new gatherings which courses are to be realized, depending on the power relations and the consciousness among those elected. Despite opposition from powerfully centrally placed members of the staff- student committee and from civil servants in the school administrations - normally men (for in Denmark men hold the leading posts, also in public authorities administration), we have succeeded twice in getting through with women-only courses about girls, women and information technology at school. The courses are really a thorn in their flesh. "They" find that it is very extreme and pure sexism to keep men out. They think that equality should develop gradually and through discussions and information -always in mixed sex groups so that dialogue is not stopped. We women claim that even though in Denmark we have had an active women's movement for more than a hundred years, we still do not have equality. Now we need the use of different means. A quota system between women and men must be made (like in Norway) and affirmative action must be taken.
This means that an active effort must be made to counteract the reproduction of old traditions and patterns in the sex divided labour market and in the homes. This can not be done through dialogue alone. It is really a power-struggle for privileges, status, knowhow, childcare or in short: a fight about the division of labour in society. And in connection with the development of new technology it is also a fight about

fixing priorities, about what is to be developed, on what ethics. and a question of whom will benefit from the decisions.
But to sum up about the women-only courses at the SES:
We have succeeded in getting our proposal through to offer the courses. (hurdle No. 1.) and a fair number of women teachers have applied for the courses and have been recommended by their head teacher (hurdle No 2.)(However, many have been sorted out at this stage, because their head teacher or superintendent of schools have not been able to see the relevans of a "women-only" course).
And the women teachers, who have attended the courses, recommend them, write about them in professional papers and to the governing organs and slowly the attitude is changing, because becoming visible is the first step.
But without networking among women it could never have worked.
This is what is common to the two projects and what we shall return to after the presentation of The Iron and Technology-project for women.

It used to be 99% men.

A women-only course at the Specialarbejderskole (training centre for skilled and unskilled workers) will start for the 3rd time in 1987.
Generally the courses at the school are called the Labour market training courses (The AMU). A large number of short training courses are offered in many different fields,especially connected to industry, for instance iron/metallic industry, electronics, computers, foods and process industry.
The subjects at the schools reflect in a very characteristic way the sex divided labour market, and normally there are less than 1% women at the technical courses.
Among other things the AMU-system is characterized by very heirarchic decision making structures and open sex segregation vertically in the organization. The men as managers, and the women in subordinate positions.
The schools are run by corporative organs in a three-party structure, consisting of the unions and the employers, organizations and technical/administrative officials. All men!
Teaching in technical areas are also done by men. Before the first women-only project in 1984,nobody at the school had thought about the absence of women in technical subjects On inquiry Kirsten Junge was told: formally there is equal admittance, so maybe the women are not interested.

In short: the reason was to be found in the women themselves, if they did not take a technical education.
Nor was it for the sake of the women, but for fear of a shortage of labour that the school accepted to start a women-only project in iron- and technology. But both among managers and teachers there was a lack of understanding of why we should plan the courses, so that they were based on the new target group (i.e. women) and their special background and experience.
But as the project was initiated as part of the public/state Equal Opportunities Policy, the school was forced to take this aspect into account. This course was pieced together from many small courses and made longer than the usual courses for men. And they ended up containing an introductory guidance period with a possibility for making a qualified choice. Beside the course was supplemented by trainee periods in the iron and technology industry.
Experiences from the Specialarbejderskole in the iron- and technology projects turned out to prove, that the main "problems" were not to be found in the women themselves, but much more in the contents of the education, its framework and the educational practise of the school.

Many examples can be mentioned from workshop- training, but the following problems show the complexity and some of the factors discussed during the project.

1. The women often were not certain if they had understood instructions well enough, because the subjects were very strange to them. At the same time they felt they could not go on asking the teacher. The women expressed how stupid they felt when they did not understand instructions at once.
2. The teachers often told the women that they would not be able to handle the machines physically, and therefore they helped the women. So it never became quite clear to the women if they themselves completed the task- or if the teacher did it for them.
3. The women often felt that they were estimated to be worse than they were. The did not have the same impression of each others skills/competence as the teacher. The problem was for instance that the work was so unknown for the women that they themselves could not estimate when the work was well done, because the teacher kept back information on what his evaluation was based.
There was no doubt that the teachers expectations of the women's abi-

lities were poorer than their expectations of men's.

4. The women often expressed that the teachers were "tough" and spoke harshly to them.

   The self-concept and use of autority of some teachers also caused problems.

The teacher is trained as a skilled worker in male blue collar jobs. The tone and the norms from his own training and workplaces he often lugs along. This can come out in several ways. Especially two kinds of authority were dominating, "paternalism" and "the good judge". The foreman" would act as a paternal, often affectionate and overprotective authority. In a relationship to a "father" the daugther is the insecure girl, who needs protection. This use of authority has a restrictive influence on the learning process of the women and also on their search for autonomy.

The "good fair judge"or foreman type was characterized by a so-called "objective" judgment of the women's achievements. As an instructor he has only one way of communicating his subjects, and does not change his instruction according to his target group.

Both "the paternal" and the fair judge type", used a oneway communication. which inhibited a dialogue with the women.

The above mentioned problems were for instance described in evaluation reports, discussed on certain days when women's only education was on the agenda, or at teacher training colleges.

In this connection I would like to describe some of the changes, which have come about through our common network.

1. Educational Debates at the School

   Firstly the school has opened up and begun to debate women's claims to the contents of education, teaching methods and structure. Women experts (the network) have with the governing bodies of the schools and male/men teachers discussed the barriers, which the women experienced during their education.

2. Seminar on education for women for male teachers

   Secondly the first residential course for male teachers was held in the spring of 1987, concerning the development of an education more suitable for women's needs. Lecturers and leaders of the seminar came from the network.

   The seminar was a success and new debating days are being planned.

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3. Teaching contents have been changed.

More general topics have been introduced into the course- as the women wished.

Courses have become prolonged to lessen the time in pressure and relieve the very tough demand, that one must not be absent from more than 10% of the course.

More common technical basic qualifications have been introduced so that there is given a greater possibility to choose other fields of education or occupation later on.

4. A two-teacher-system with a woman fitter and the employment of an additional women teacher

In aknowledgement of the educational problems which arose at the school, it was decided to employ a women fitter. Partly as an aid in educational development and partly as a role model for the women.

One single example may illustrate some of the types of problems, which arose during the project.

The teacher demonstrates how the grinder works, and soon after the instructor leaves the room.

The two women, who are trying to grind, don't dare to start, because they think that the "sparks" will burn. And they dare not reveal their fear and insecurity to the teacher.

In this case the teacher has not imagined at all "that anybody believes that sparks from a grinder might burn". Nor does he have time to make sure the participants have understood instructions.

A different type of problems appeared in connection with the height of the machines, physical demands and equipment developed for men's physique. Now an assessment must be made of the changes which must be made technically to set things right, while also the women get an opportunity to get to know their bodies better and maybe get a greater body-consciousness. (both women came from the network).

Networking
- a way to survive and go forward.

How do we as individuals overcome male dominance and resistance which undermine our actions to support and develop the power of girls and women?

Firstly we find it important to be women indentified.

Besides we must be well qualified and well prepared. But this is still not enough to overcome the barriers and the resistance -open or hidden - because we are up against questions of power, influence status etc.

Being politically active and intellectually clever is not the same as being psychologically strong.

We have to cope constantly with the contradiction between male superiority and our own self-esteem. The networking helps to keep-up the selfrespect.

Different networks are important in different situations. When enumerating the groups of women, whose support we can count on, the two of us together have around 10 of whom some are identical.

And some of the networks are more loosely structured than others, which function with fixed dates and recurrent arrangements, but it is characteristic that they can all be called together when necessary.

As support for the women project at the Specialarbejderskole there are around 15 women : politicians, researchers, union representatives, workers, teachers, and project leaders, who turn up to qualify the debates.

On a countrywide basis a Forum for Women Researchers at the SES has been formed, as a result of the debates on equality, women's research and sexual politics at the SES, and at the Århus branch there is the Equality Group, who develops and formulates courses and research projects, and the local branch of the National Union of Teachers has an Equality Committee, who supports initiatives to further equality for instance at the SES. In this connection the international- both European and world wide- networking. which has been built up via the NGO - UN conferences. (Mexico, Copenhagen, Nairobi) has been of great importance.

The GASAT conferences,not least the reports from these conference,are of great importance when we have to convince politicians and planners.

An example of one of the danish netwokrs is The Danish GASAT FORUM, which originated from the 3rd. GASAT conference, and whose members have professional discussions, and who arranged The European conference Women Challenge Technology (Nov. 1986).

Altogether these women networks are promoting development, experiments and exchanges, which in this relatively small country have an effect, which can be seen in both legislation planning and in appropriations, and which help to create an awareness and political opinions which we hope will be at benefit to women, the Women's cause and society in a whole.

THE PROGRESSION OF WOMEN INTO TECHNICAL TRAINING

MEG McDONALD & RAMONA STERLING

F.H.E. CURRICULUM DEVELOPMENT PROJECT. I.L.E.A.

This 3 year project has set out to analyse the mathematical, scientific and technical skills women acquire in their traditional roles and education. Skills that society and possibly women themselves do not realise they have.

If the skills women acquire are common to those acquired by men during education then this understanding should make it easier for women to progress into wider occupational areas i.e., traditional male occupations.

Planning

a) Analysis of the curriculum of science, technical and craft related courses in relation to process skills. Compatibility of the process skills relating to 'traditional female' subjects.

Development

b) Selection of the sample.

c) Development of the questionnaire, process skills checklist and other related materials.

d) Staff development with teachers involved with WITT, (Women Into Technical Training).

Action

e) Implementation in the classroom, profiling students using the process skills checklist as a means of continuous accreditation of competences.

Evaluation

f) On going through staff development. Visits to institutions, discussions with client group. Final evaluation when all data has been received.

Sample

The first part of the work investigated subject areas designated by society as'traditionally female'. The sample chosen included girls in their 5th. year at schools and adult women over 25 years in colleges of Further Education and Adult Education Institutes.

The second part of the work examined vocational courses in subject areas designated by society as 'traditionally male'. This consisted of women under 25 and women over 25 in colleges of Further Education and Adult Education Institutes.

Process skills checklist

A tool was needed to identify and accredit those skills which were common to the curricula in 'traditionally male' and 'traditionally female'.

The process skills checklist used was derived from:-

- investigation of the skills underlying the practice in a range of foundation and other courses in schools and colleges of Further Education, which are predominantly scientifically, technically and crafts based.
- analysis of an existing comprehensive range of skills checklists.
- finer detailed work with the R.S.A. (Appendix 1).

It has been noted that these skills were equally applicable in traditional male and female areas and that there were many instances of similarity, i.e., icing a cake and plastering a wall had similarities of consistency of mixture, application and smoothing techniques

Questionnaire

a) The problem areas surrounding the progression of women into technical training are wider than problems of skill acquisition or clarification. They have also to do with attitudes of society, expectation and self-image. Therefore, to make a fuller analysis it was necessary to have an additional tool to the skills checklist. To acquire more information on the sample that might have a bearing on outcomes and implications of checklist analysis.

b) There was a need to find out more about the effects on learning and career aspirations, of courses taken while at school and of attitudes of students, teachers and society/peer groups.

c) The school and college questionnaires needed to be different in some aspects in terms of added experience and monitoring progression.

The following are some of the points emerging from a preliminary analysis of the questionnaire:

i) Very few girls and even less women have positive attitudes towards science and technology.

ii) The most popular science subjects chosen by the sample are the biological sciences and 'science at work', the least popular being physics and chemistry.

iii) Teaching methods and unsympathetic teacher attitudes were often mentioned as reasons for not enjoying science, e.g. 'The teacher did not explain'.

iv) Where girls made positive statements the most consistent themes were enjoyment of practical work, solving problems and the use-

usefulness to everyday life situations.

v) Craft, design and technology was popular but still very few girls chose it as an option in the 4th and 5th year (maths and science were usually compulsory)

vi) Most of the girls had experienced and used computers at school. Positive attitudes were expressed when the use of computers could be seen to be relevant and applicable to the subject being studied.

vii) Few girls considered careers in science and technology. Parents, career teachers and friends were the most influential in career choices. Girls opting for'non-traditional' careers had in most cases been decisively influenced by a relative, usually a man. Courses most desired were those which could provide qualifications for 'traditionally female' areas.

viii) It was noted that subjects such as maths, geography,graphical communication and home economics were seen by the young women to involve the use of most scientific and technical skills., geography being top of the list. Also that these were not confined to school. Cooking, shopping and looking after children were percieved to include many of these skills.

ix) Sex stereotyping was seen to be firmly entrenched in the girls views of job suitability.

x) Awareness of the range of jobs within the science and field varied from school to school. Girls from co-educational schools had a wider more varied view. Careers advice in these schools may provide information on a wider range of jobs to accomodate the needs of males.

Summary and conclusions

The main aim of the W.I.T.T. project is to facilitate access for girls and women into technical and scientific education by accrediting them with technical, scientific, mathematical and communication skills i.e. process skills. A further aim is to change attitudes, develop awareness and confidence and encourage girls and women who have been 'switched off' from considering further educational and career opportunities in the science and technical field.

The work of the W.I.T.T. research project has so far shown that:

i) many girls and women possess the necessary skills and abilities which would enable them to succeed in the technical field.

ii) recognising the science and technical content of'traditional female' subjects and the skills developed within them, help the students to overcome many negative attitudes towards science and technology. It also raises the tutors expectations of girls and women.

iii) parental attitude and advice and the advice of tutors and careers advisors is crucial in influencing career choice.

iv) the adverse effects of stereotyping in the social and educational environment is evident in the folowing areas:-

a) Self-image
   - lack of confidence and assertion to tackle certain areas of learning and self promotion e.g. areas regarded as 'traditionally male', applications and interviews.

b) Transfer
   - the ability to transfer practical and academic skills already possessed from one context to another.

c) Teaching / learning
   - where learning is hindered by teacher expectation and presentation of content.

d) Support

- where the varying needs of students are not taken into account. Creche facilities, advice and counselling will facilitate the ability of the students to focus on their studies.

e) Progression

- where stereotyping jobs and courses causes students to pursue narrower vocational and life options than is necessary or desired.

v) motivating girls and women towards scientific and technical subjects appear to lie in modifications to the curriculum and the teaching strategies employed. W.I.T.T. project work and other research and surveys show that women and girls are more motivated towards science and technical courses which:

- have a humanistic element
- provide plenty of opportunityfor related practical work
- includes social and environmental implications
- provides open ended problem-solving situations
- is relevant to students own lives

There are situations where it may be appropiate for girls or women to be taught in single sex groups and these have proved to be very successful. It would also seem necessary on these courses to give experience at an appropiate stage of working successfully in a mixed group, to allow continued success and confidence outside the course.

It has also been shown that given the'right approach' girls and women have been successful and happy in mixed groups with male or female tutors. Each situation needs considerate analysis.

Recommendations

There is a need for in-service training for teaching staff to help them consider and modify the curriculum and teaching approaches, to take into account the learning styles of girls and women. A change that has been shown to benefit all students, male and female.

Efforts by schools to inform female students and relatives of opportunities available in the science and technical field are important. Annual technological exhibitions and events where students and relatives are given information on courses and subsequent careers, have hands-on experience and meet people from 'traditionally male' areas, have proved successful. These are best aimed at third year students before option choice time but is also beneficial to attitude change in other age groups.

W.I.T.T. has highlighted the importance of identifying maths,science and technical skills within'traditionally female' areas. Science, maths and technical departments need to liase with these subject aereas so that tutors can devise curricular and teaching stategies to enable girls and women to transfer these skills and knowledge.

It is important that colleges allow flexibility in their selection procedures and entry requirements. Recognising the skills women bring and non-standard forms of accreditation.

Preliminary introductory and short diagnostic courses are of great value. Such courses could provide the right environment to foster skills transfer, for women to develop confidence and to fill any gaps through lack of specialist experience.They would also aid progression and help access into mainstream 'traditionally male' programmes.

The W.I.T.T. research project is in the final stages and is due to end in July 1987.The following will be available shortly.

a) A formal report

b) an informal report and handbook

c) A video

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GIRLS AND SCIENCE AND TECHNOLOGY

PROCEEDINGS

FOURTH GASAT CONFERENCE 1987

The Univeristy of Michigan, Ann Arbor, Michigan U.S.A.

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Jane B. Kahle Jane Z. Daniels Jan Harding

PROCEEDINGS

FOURTH GASAT CONFERENCE

University of Michigan
Ann Arbor, Michigan, U.S.A.
July 24-29, 1987

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Welcome to GASAT 4!

Opening Remarks

Jane Butler Kahle, International Convenor
& Chair of the Planning Committee

History of GASAT

In 1979, several concerned researchers in Northern Europe met informally to discuss their work concerning the access of girls and women to careers in scientific and technological fields. As they shared information, it became obvious that the issue crossed national boundaries and cultural differences and that many initiatives were being taken to increase both access and retention. Therefore, they proposed an international symposium so that all women and men working in projects about girls and science and technology (hence, the name, GASAT) could meet together, share their experiences, and learn from each other.

The first international forum, held at the Technische Hogeschool Eindhoven in 1981, was sponsored by the Dutch Department of Education. Participants were invited from Western Europe and North America. In all eight countries were represented: the Netherlands, England and Wales, Sweden, Norway, West Germany, Portugal, the USA, and Canada. Participants at the first international GASAT forum divided into three working groups in order to discuss the following issues: teacher education, support for girls and women, and curriculum and teaching materials. Accepted papers were published as Contributions and distributed before the meeting. In addition, GASAT produced Proceedings of each forum, and the first GASAT published a Congressbook.

The second GASAT forum was held in 1983 at Sanner Turisthotell, Hadeland, Norway. Financial support was obtained from several ministries of the Norwegian government as well as from Narst Hydro, Norwegian Telecommunications, and the University of Oslo (the host institution). Fifty-five participants and committee members attended the conference, representing Norway, Sweden, Denmark, England, the Netherlands, West Germany, Italy, and the United States. Broader issues as well as more sophisticated studies marked the GASAT 2 papers, which were discussed in the following groups; sex stereotypes and interactions, curriculum, intervention programs, and teacher education.

GASAT 3 was held in 1985 in London with Chelsea College as the host institution. Both international and national planning committees were formed. The international committee was committed to broadening the scope of the conference and its participants. Over 100 participants representing 20 different nations, including Australia and New Zealand as well as four African and three Eastern European countries, attended. GASAT 3 focused partially on the research which evaluated the intervention projects which had occurred since the original GASAT forum.

GASAT 4, hosted by the University of Michigan, has 156 registrants, representing 31 countries. We have reached out to Asia and to the Americas with participants from the Peoples Republic of China, Thailand, and Jamaica for the first time. Our theme - A Celebration of Diversity - synthesizes the direction and intent of GASAT 4; for example - the diversity of women, the diversity of science, the diversity of involvement and/or interaction as discussed in the papers, and the diversity of gifts as represented by our corporate, educational foundational sponsors.

Purpose of GASAT

As I see it, GASAT has evolved from an informal network to a sophisticated international forum. Originally, it served as a support group for isolated and, often, insulated independent researchers from developed nations. As GASAT matured, both the number and diversity of participants increased as well as the breadth and sophistication of their papers. The evolution of GASAT is clearly seen by scanning the Tables of Contents of the volumes of Contributions from the four conferences. Increasingly, the work reported has become more experimental and less descriptive; that is, research and evaluation rather than intervention and example are stressed.

Future of GASAT

As each of you move through the exciting five days of GASAT 4, I want to ask you to focus on the future - not just of GASAT - but of the issue that brings us here; that is, the attraction, retention, and achievement of girls and women in scientific and technological courses and careers. What should be our future direction? How do we formulate and investigate a theoretical basis for our research? How can we adapt and use scientific paradigms in our work? Let us resolve to move beyond discussion and action to a theoretical articulation of both problems and solutions. I welcome each of you on behalf of the Planning Committee and the International Committee.

Cherrill Spencer, a GASAT participant, wrote a lengthy and entertaining report of the conference for the Math/Sci Network. She graciously edited and amended it to include it as our conference summary.

GIRLS AND SCIENCE AND TECHNOLOGY: THE FOURTH BIENNIAL MEETING

by

Cherrill Spencer & Jane Butler Kahle

"Chinese Women Rise With Force and Spirit in Science and Education" (China)

"Desexing Computing" (England)

"Are Women Able to Change the Image and Content of Science and Technology?" (Finland)

"Women in Science and Technology - Problems and Prospects in Kenya" (Kenya)

"A Pilot Study of Malaysian Form Four Girls' and Boys' Conceptions on Electricity" (Malaysia)

Those are just a few of the titles of the 132 papers submitted to the fourth international conference of "Girls and Science and Technology - GASAT 4" held from July 24 to 29, 1987 in Ann Arbor, Michigan. One hundred fifty-six participants from 31 countries discussed papers which aimed to increase international knowledge and understanding of the value and diversity of the contributions of girls and women to science and technology as well as the issues that affect their contributions. It is difficult to summarize 1150 pages of fascinating research projects, case studies, intervention descriptions and evaluations or to capture the intensity and personal joy of spending 30 hours in formal reviews and discussion groups with like minded teachers and researchers.

The first GASAT meeting was held in the Netherlands in 1981 and its original purpose was as a support group for individual researchers and people working to increase the access of girls to science. The next two GASATs also took place in Northern Europe, in 1983 and 1985, with an increasing number of attendees from more and more countries. The fourth GASAT was the first to be held outside Europe and it has evolved from a support group into an international forum where experts articulate the theoretical basis of this issue and describe the methodology and results of carefully designed research projects.

In response to concern expressed at GASAT 3 that GASAT 4 would be overrun and dominated by Americans if it were held in the U.S., the Planning Committee restricted United States attendance to 20 percent of the total, so there were 27 U.S. participants plus 10 organizers and some student rapporteurs from the U.S. The 156 participants were mostly women and men in the field of science education: primary/elementary school teachers, junior high and high school teachers, and university professors (in psychology, sociology, education, engineering, math, biology, chemistry, and physics). Participants also worked in public education offices, some of whom were involved in developing new curricula. There were also participants working in governmental agencies, in non-profit organizations, in labor unions or professional organizations, and in various "girls/women in science" projects. In addition, a handful of participants worked as scientists in industry. In all there were nine male participants.

Virtually every conference participant had submitted an eight page paper several months before the conference which was appropriate for one of three main themes: Research, Evaluation, or Intervention Programs. Papers were reviewed, categorized, and published as Contributions. The resulting three volumes were sent to participants some weeks before the conference.

The conference followed the format of previous GASAT meetings; that is, invited discussants summarized and synthesized papers within each category.

Each day one theme was highlighted, and, following the discussant's summary, participants selected a small interest group which focused on one aspect of the theme presented. (FIGURE 1)

Among the questions discussed in small groups at GASAT 4 were the following:

- * Why do we want more women in science and technology?
- * How realistic are students' perceptions of scientists? Can and should these be altered? If so, how?
- * Is there a conflict between freedom of choice and the recommendation to make science studies mandatory for all?
- * How do we make sure that girls and women get a constructive/critical attitude towards technological development through our interventions?

In addition to the theme presentations and discussions, workshops and special interest seminars were held. For example, Anna Lea, Norway, presented a workshop on the Girls into Science Project at the University of Oslo, while Jacquelynne Eccles and Judith Meece, United States, chaired a seminar on qualitative research methods.

The forum also provided many opportunities for informal exchanges during meals, daily wine & cheese parties, and receptions. Participants and observers (attendees who had a special interest in the issues of GASAT, but who did not submit papers) enjoyed the large resource room, stocked with project ideas and sample materials. A trip to Greenfield Village provided our international visitors with a glimpse of our history and our technology. Many participants enjoyed the suffragette who spoke on the school house steps during our tour.

The final day of the forum featured a plenary session where a critique of the women into science and technology movement was presented; where individuals commentated on the mission of GASAT, the politics of the U.S., and the organization of the conference; and where the forum was evaluated informally. One of the conference highlights, the Squibb Science Seminar, concluded GASAT. Both international participants and participants in the ancillary U.S. conference, which followed immediately, were treated to a lunch and three invited papers. Those papers, by Leslie Parker, Australia, Jan Harding, United Kingdom, and Lilli Hornig, United States, examined the issue of feminine vs. masculine science. Each speaker presented a different perspective; their papers are found in this volume.

GASAT 4 was followed immediately by a two-day national GASAT conference: "Women in Science and Engineering: Changing Vision to Reality". About 200 women educators, scientists, and engineers attended. The U.S. conference was organized by the Office of Opportunities in Science, American Association for the Advancement of Science, and was structured to focus on generating solutions to the problem of achieving equity in science and engineering. During the U.S. conference, there were four plenary sessions and six panel presentations with experts presenting the latest research, data, and intervention programs. In between, small discussions groups were held in which lists of recommendations for general and specific action in terms of future research, long and short term strategies, and policies were developed. Those lists are available from AAAS.

The U.S. Planning Committee opened up the international conference to a more diverse group than had attended previous GASATs by obtaining funds for travel and subsistence for virtually all international participants. The size of the conference concerned many past attendees, but the forum's theme, "A Celebration of Diversity," was met. GASAT 4 struggled with real issues involving the full participation of women in science and engineering. At GASAT, we listened, we questioned, we argued, we compromised, and we learned.

8

THE INTERVENTIONS REVIEW

By Anne-Mette Kruse and Benthe Stig, Denmark

In the papers on intervention we see four major aspects:

1. The linking of research and practice
2. The importance of working at many different levels, in many different ways
3. Making use of networks/friendship groups
4. The question of co-ed or gender segregated education.

Theme 1

The Linking of Research and Practice

Since the beginning of the 70's Barbara Sprung (Vol. III, p. 359) has been developing curricula, teacher and parent programs, films, and hands-on classroom materials and toys, seen from the broad equity perspective of people from USA: as to gender, race and disability. In her paper she describes the project Beginning Math and Science Equitably, funded by the US Education Department, Women's Educational Equity Act, of which she was the director in 1983-84. The aim was to develop an early childhood curriculum that would promote the development of visual-spatial, problem solving and creative thinking skills.

Heather Johnston Nicholson and Ellen Wahl Sullivan from Girls' Clubs of America (Vol. I, p. 331) emphasize already in the title of their paper "Operation SMART: From Research to Program - and Back" the linkage of research and intervention. Operation SMART, a program offering fun and educational experiences in math, science and relevant technology, defines its goals as helping girls acquire an attitude of scientific inquiry.

The Operation SMART model has what they call "six easy pieces" including scientific inquire, an approach that pervades the entire program; scheduled sessions in science, math and technology for small groups of girls, held once or twice a week for an hour or more; incorporation of math and science and an attitude of scientific inquire in all club activities and policies; career exploration; family involvement; and community connections.

The attitude of making the girls question instead of just giving them the answers is not easy to teachers who are used to traditional teaching. And it is certainly a challenge to the whole staff of the girls' clubs to incorporate math and science and an attitude of scientific inquiry in all club activities and policies. Members of staff may suffer from the same feelings about math and science as do the girls. In Boston they solve this problem through a project called Museum Link which means that club staff are brought to the Museum of Science for training in scientific inquiry and hands-on science. The museum also offers technical assistance and practical advice.

Helene Sorensens (Vol. II, p. 343) research in gender-;inked differences in interests and attitudes to science in Denmark shows results very similar to the ones presented by British and Norwegian researchers at the earlier GASAT conferences. But it has proven very important to have Danish findings, since just now the Danish Minister of Education has set up committees to change the science curricula in secondary school as well as "gymnasium" (almost=high school). In both committees are two women, Helene Sorensen being one, and the committees seem to listen to the arguments that science must be linked to the everyday experiences of girls in order to make them interested.

The purpose of the paper is to examine the extent to which women living in rural parts of Nigeria adopted a variety of technologies introduced to them. The technologies had been introduced to the women through 8 different projects, among which were one on developing women's cooperatives and one on family planning.

Adefolu Akinbode has the following conclusions to his findings:

- the women desired to determine and regulate their actions rather than being subjects of stereotyped government regulations
- with provision of ingredients for family planning and support from their reference group (the men) they will adopt family planning
- they were capable of making judicious use of loans
- with improved management skill and elimination of issues of role conflict, they will do well in agricultural technologies
- profitability, costs, and availability of materials were major determinants of improved nutrition practices.

Theme 2

The Importance of Working at Many Different Levels, in Many Different Ways

Jo Sanders, Women's Action Alliance, USA (Vol. II, p. 303), "Closing the Computer Gender Gap in School". The paper suggests strategies for minimizing the gap between girls' and boys' use and attitudes toward computing. The first step of this intervention project was to develop a "speculation list" of possible causes of the computer gender gap and take it to the teachers and administrators of three schools asking them to choose which, in their experience, were the likeliest culprits and devise strategies to counteract them. Each school implemented four to six strategies, and informal results indicated that most of the strategies seemed to encourage the girls. The strategies made part of the book "The Neuter Computer" which again made part of a strictly formal field test with control group, attention control group, and keeping of student computer-use records. The field-test lasted one term, and the results were: Control school no increase in girls' computer use. Attention control school which had received a faculty workshop and reminders of the project every two weeks, registered a 14% increase, while the three experimental schools had an increase of 144%. The experimental schools had had the same faculty workshop and bimonthly calls as the attention control school and in addition The Neuter Computer. They had followed the guidelines and chosen a variety of activities.

As major lessons learned from the project Jo Sanders mentions: Target girls clearly, not "students", "all students". Even "girls and boys" will be translated as "boys". What she urges us to say is "Computers Are For Girls". Target girls in friendship groups, not individually. "Adolescent girls are intensely social creatures. They stay out of the computer room if their friends, who at this age are likely to be other girls, are not there." Make computers useful. Girls tend to want the computer to do something useful like making homeworks easier or better or enabling them to do non-school things better. You can start low, bud don't stay there. No girls should be allowed to stay at an elementary level.

The group of six women from Linkoping University, Sweden, Ingrid Granstam et al. (Vol. II, p. 281) have 8 years of experience in increasing girls' interest in technology, and their paper may be used as a guide to successful practices. They do:

- mini-courses for girls in upper secondary school and now also for girls in lower grades, realizing that the first choice towards the future career is made when the student selects an upper secondary school program.

- visits to schools by women students from the institute of technology. The students inform the girls of their experiences of studying at the institute, but they also serve as instructors, helping the girls carry out experiments in small groups
- special projects, e.g. introducing technology at the dept. of nursery school teacher training of the university.

It is a paper that gives a lot of practical advice to those who want to target girls and teachers.

Walter S. Smith, University of Kansas, describes COMETS: Evolution of a National Women in Science Program (Vol. II, p. 335).

The program holds a two volume curriculum to supplement the already-adopted curriculum of a teacher or school. The idea is to, at the same time, expose students to women role models and to show them that science is used in all kinds of careers in their own community. In order to achieve this the program makes use of three kinds of role models: A "community resource person", the "historical role model", and the "contemporary role model".

The most inspiring thing about COMETS is perhaps the way the message is disseminated. Once the book was printed, the attention turned to training teachers through workshops. And when many more disseminators were needed, COMETS Workshop Leader's Guide was published in spring 1986, and some 1500 complimentary copies were distributed to key persons. Next came the production of a COMETS Workshop Leader's Videotape, complimentary copies being placed in each state in spring 1987, circulating through networks for use and for free copying.

Fascinating also is the project TEAMS from Indianapolis, training multiple groups of seven each: a science teacher, math teacher, counselor, building level administrator, central district administrator, parent and student, and making use of both COMETS and EQUALS.

Christine Kahan Black (Vol. II, p. 261) has in her paper described a special issue: Opportunity in science for women with disabilities. Not surprisingly the barriers for disabled are even higher and tougher than ones girls usually meet. Accordingly, it is crucial to have good role models to show the disabled persons themselves, their families, teachers, and also employers that disabled can be "science-abled". But one problem is that owing to these barriers there are very few role models. So the project has produced two videotapes, one for students and one for employers, showing some of the few role models that exist.

The paper of Jane Daniels (Vol. I, p. 296) gives good inspiration to the many different ways you can work for recruiting women into engineering. One of the strategies they use at Purdue University is continuity of contact which means that the Women in Engineering program provides continued contact with students from junior high school through their enrollment at Purdue.

Aina Schoitz and Gro Hanne Aas from Norway (Vol. II, p. 317) write on recruitment strategies, too, but on a different level, recruitment to research positions, and focusing on the open and hidden institutional barriers. Their background is that they work in the Secretariat for Women and Research under the Norwegian Research Council for Science and the Humanities. Science in this case also includes social science, and technology has been included, too.

None of the employees of the secretariat had any experience as to natural science or technology studies and research. So they had a double need to start by building a network. They were totally dependent on connections to persons and groups who worked in these fields and were sympathetic to the ideas so that they could develop the strategies together. And they were dependent on local forces to implement the strategies at the various universities.

One thing that is important is to make the existing women scientists visible, and as a means for that they have made a survey of approximately 170 women scientists and technologists. Having such survey you know where to look for potential members of a network, where to look for lecturers, teachers and supervisors, where to find women with certain expertises, where to find role models. Other things that the secretariat has done, is to start research projects, one on concealed gender discrimination in evaluation and employment procedures for academic positions, and one on how women's interests can be incorporated in future research.

Theme 3

Making Use of Networks/Friendship Groups

Nancy Kreinberg of EQUALS (Vol III, p. 336) focuses on our global responsibility, deeply influenced by her participation on Women's Forum in Nairobi last summer. It is not enough that we provide girls with the qualifications to compete on the good jobs. She stresses that it is important for U.S.-women - and we may as well say women of the Western hemisphere - to understand the implications of technological development on other populations. The policy and decisions that are made about the direction and priorities of new technologists have been made by men in Western industrialized countries, with virtually no input from the women in these countries nor the people for whom the technology is intended. As women, she adds, we have been unsuccessful in determining the development and directions of the new technology. We cannot afford to remain outsiders to these decisions any longer.

Pauline D. Pages from the Philippines and her paper on Rural Women in Ornamental and Medicinal plants (Vol. I, p. 340) reminds us that not all technology is high technology, and that our responsibility as women of the third world, and how technology is implemented in that world.

Eleanor Ling, USA (Vol. I, p. 314), and Margaret J. Morton and Barbara Reilly from New Zealand (Vol. I, p. 324) both connect to EQUALS. It is great to learn how the ideas of EQUALS are implemented in respect of local differences.

Janet Burns, also New Zealand (Vol. II, p. 266), describes the awakening awareness of the gender gap in science and the beginning work of two network groups for women in science and engineering.

The paper by Lisbet Roepstorff, Anni Korsbak, and Benthe Stig from Denmark (Vol. III, p.) tells of a network group of some 20 women teachers from primary school up to technical and commercial colleges, all with the common interest in gender, schooling and the implementing of technology in education.

The group was initiated in 1984 and has sine then met regularly in consciousness-raising seminars and hands-on workshops, e.g. an EQUALS seminar and a course in teaching elementary technology in primary and secondary school. The teachers got inputs as well on gender problems as hands-on experiences. And during the course they developed, implemented and evaluated curricula for the different age groups.

Margaret Ann Armour, Canada (Vol. I, p. 275), tells of a summer research program for grade 11 high school girls at the University of Alberta, Edmonton. The program is meant for girls who are qualified for scientific/technical studies, but who have so far not considered such careers, and after only three years this rather small scale experiment has proved effective. A number of the participants are now studying science and engineering. The network idea of the project is that girls after the course should influence other girls from their classes to consider science as a career.

Joke Tromp (Vol. III, p. 367) comes from the Committee on Women and Science in the Netherlands. The title of the committee sounds very official - and that can be very practical for an organization that wants to be a policy maker. But the name covers some 30 people who seem to accomplish a lot in their spare time. Their aim is to increase the participation of girls and women in science education, mainly focusing on the secondary education level. They hold regular meetings where one member will give a lecture on her or his activities. Also they discuss govermental policies as to science education, and when they have come to a mutual standpoint, they let the authorities know. They write all sorts of articles on the subject, they attend workshops, meetings and congresses, they make pamphlets and posters and so on. The committee is only five years old, but has succeeded to be an institution that is heard, represented in ministerial commissions, etc.

Theme 4

Co-ed or Gender Segregated Education

Anne-Mette Kruse and Kirsten Junge from Denmark (Add., p. 47) take their starting point in the fact that in reality - though not in formality - there exists a strong sex segregation in the labor market and also as to which educations women and men take. And they put forward the paradox that in order to counteract this segregation which obviously favors men they have found it a powerful strategy to develop women-only courses in the field of technology, instead of the usual male-dominated ones.

Anne-Mette Kruse has initiated university level courses for women teachers, while Kirsten Junge has initiated courses for adult unemployed non-skilled women workers. They want to qualify women to take wider educational or occupational choices than women usually do and, experience traditionally male areas without male dominance. They want courses that build on the women's own experiences and qualifications, courses that will not let women feel inadequacy or fear of technology, and where they can develop a professional identity without any pressure for achievement and competition. During the courses they want the women to build networks, to develop both self confidence and solidarity.

One more reason for those courses is that we need women's values to influence the technological development.

Hjordis Beyer and Marianne Abrahamsen, also Denmark (Vol. I, p. 2839, have experienced the benefits of women-only courses, having joined co-ed and sex-segregated computer courses as well. One of them is now involved in a high school project, special curricula in experimental classes. The classes are not sex-segregated, but for example practical group work in physics has made use of girls-only groups as well as they have dealt with a sewing machine rather than a steam engine.

They let groups practice in industry to put the theoretical teaching into concrete frames, which fulfill the girls' wishes to see the practical implementations. And they include drama as an integral part of the teaching.

Margaret Rogers, England (Vol. II, p. 296), is now doing teacher training, but she has been actively involved in setting up a department for Craft, Design and Technology at Elizabeth Garrett Anderson School, a newly amalgamated girls' school in London that has one of the most progressive curricula we can think of. This school, which works in a multi-cultural, mainly working class area - is a challenge to all of us that are today engaged in the education of girls and young women to make them broadly qualified in both handicrafts, arts and sciences and to give them good possibilities to be subjects of their own lives.

Margaret Rogers has developed - or out of the practice evolved - these aims for CDT:

- to develop designing skills in the pupils to help them exercise their curiosity
- to enable pupils to formulate their ideas and express them
- to develop in pupils the ability to relate function to design - finding out - and making things work
- to provide situations where pupils can test, evaluate and ulti-

mately take responsibility for their own actions.

- Accessibility is not only good facilities and good educational environment and teaching, but also - Margaret Rogers points out - that the other staff-members "make room" for this new type of education in the curricula.

The whole staff on these courses have been women, and as the school is single-sex, external pressures do not affect the option choice in the way it does in co-educational schools. The department is very democratically run, and barriers between disciplines have been overcome.

In the following five papers adult women are the target group.

In the paper of Kerry Mullins-Gunst, Australia (Vol. I, p. 307), the target group is students who have excluded math and science in their final year of secondary schooling and thus excluded themselves from post-secondary studies in math, science, and technology. The majority of these students are women.

April L. Gardner, USA (Vol. III, p. 324), faces the problem that as the successes of intervention programs in elementary and secondary schools are realized, strategies to increase females' persistance in science-related fields will become even more crucial. She describes the development of one such program, a career planning seminar for college biology majors.

Mary R. Anderson, USA (Vol. III, p. 300) describes initiatives to encourage and support women bachelors in engineering and computer science to re-enter university to graduate.

Ruth Carter, England (Vol. II, p. 274), is a member of the

WISE working group - Women Into Science and Engineering - at the Open University in the United Kingdom. She raises the question whether or not an open university can attract more women to technological studies.

Finally Ellen Sessar-Karpp, Federal Republic of Germany (Vol. II, p. 329) tells of an integrated project on computer literacy, for women and by women. The project has now resulted in the founding of a new women's training society called Institute for Future-Oriented Education and Training for Women.

The five projects take the mutual point of departure: the GASAT problem, the under-representation of girls and women in science and technology. But the approaches are different.

Kerry Gunst's "Second-chance-courses" is purely co-ed, but the structure and the contents have tried to incorporate experiences earlier described by Jan Harding, Kirsten Junge and Barbara Smail. Still, it seems as if the atmosphere of the university has made it necessary to smuggle the woman-friendly elements into the program.

April Gardners' biology career planning seminar enrolled twenty women and two men in the fall, 1985 semester. The class sessions went for two hours a week during the first eight weeks of the semester and covered a variety of topics. During the last half of the semester class participants interviewed a person in a career of interest to them and prepared a report on the interview.

The seminar evaluation was very positive, and April Gardner concludes that career-planning seminars which provide a supportive environment while addressing issues such as career development and family/career conflicts, can remove some of the social barriers that make women drop out.

The graduate re-entry program that Mary R. Anderson describes started its first class in June '82 with 28 women students. they had held bachelors' degrees for at least two years and had completed at least one yer of calculus. They were unemployed in a technical area or underemployed in terms of potential. Most of them completed a Master of Science degree in Industrial Engineering in 12 to 19 months.

The program goes on and is designed to prepare women for meaningful, productive and rewarding careers as Information Systems Specialists or other careers related to industrial and management systems engineering. The program gives special support to these students, and Mary Anderson stresses that perhaps most important to the actual survival of the participants in the program has been the peer group support.

Supporting students who are not going to have their daily life at the university is the difficult task of the WISE working group at the Open University, and Ruth Carter writes that it has had some success and suffers some frustration.

When studying technology at the OU one starts with a one year foundation courses "Living with Technology". It was the faculty's view that this course was very appropriate for women coming fresh to the area, and that it would make them feel more confident and better prepared to tackle higher level courses. So the WISE-group made it their aim to improve the number of women on that course. The publicity campaign emphasized the way in which the course deals with the impact of technology on everyday life and its assumptions that students will not have undertaken any previous mathematical or technical study. The campaign has contributed to a slow but steady rise in women students.

To support the women students the WISE group has influenced the faculty policy to appoint women tutors wherever possible, which unfortunately still is less than 10%. A CAREERWISE booklet shall help the students overcome their doubts about own suitability for technical careers and for coping with the family/career problem. A Women in Technology bursary scheme provides financial support and special counseling.

Ellen Sessar-Karpps project is a feminist initiative against a technological development in which the use of word processors, calculating software and personal computers leads to women's loss of jobs at the same time as it creates new jobs for which the displaced women are usually not qualified.

Women's participation in further education and training programs is much lower than that of men, especially when it comes to technical and computer-oriented programs. There are many reasons for that. One reason is that many programs have been conceived by and for male employees and their interest, at times suitable for them. Very few programs take into consideration women's needs, interests, their living conditions and their learning biography.

The complexity of reasons hindering girls and women from making use of offers available was a starting point for the development of special training programs for women. The first project started in Berlin 1984 and was called "no fear of computers". In Hamburg they started "Computer courses for women by women" in 1985. Since then, nationwide feminist groups have been trying to start similar projects. The idea is not only to enable women to make intelligent use of the computer as a tool, but also grasping some of the overall socio-economic and political implications of new technologies.

One paper we have not been able to put under the themes we have set up. It is by *Wang Hong*, China (Vol. III, p. 331), and on her experiences with her own daughter she writes on the effects of stories, toys and games, in science and technology education for children. She has used story telling to develop the child's language, since she was only some months old. She has found that children at an early age like toys that can be used for problem solving. The children wish to satisfy their curiosity and thirst for knowledge which are aroused by toys, she says, and recommends the seven piece puzzle which is a traditional Chinese toy that makes the children master some simple geometric knowledge. Wang Hong also stresses the social and logical thinking qualifications children get from their games, and she trusts that every child may develop all-round if taught in accordance with her or his aptitude. This is what Wang Hong has tried to do to her daughter, and as she says, so far she has won initial success. We wish her success for the future, too, raising the following topic: *Do we work for our daughters*? *Do we work for the needs of today's society*? *Are there contradictions*/

In other words: What do we want our efforts to lead to? Are we adapting girls and young women to the needs and premises of the labor market, or are our strategies true emancipation? Is it equality we want, or do we have feminist goals beyond that? And how do our goals get implemented in our practice?

All summaries were prepared by Dr. Jan Harding using notes by the student reporters.

INTERVENTION

Questions for Discussions

1. Why do we want more women in science and technology?
2. What are the implications for our practice?
3. How do we make sure that the technology we develop benefits women and generations to come?
4. How do we, through our interventions, make sure that women develop a constructive and critical attitude towards technological developments?
5. How can we, as women dealing with technology, practice solidarity with women of the Third World?

Discussion in each group was focused on a different level of education training (primary, university, etc.) or on employment.

Summary of Discussions

1. Theoretical understanding and more women in science/technology

Across the groups, two main points emerged relating to social justice and values expressed in science and technology.

- a. Social justice - This point involves the actualisation of potential (possessed by women as well as men). It requires the same empowerment of women as of men, through science and technology, in decision-making and in employment participation.
- b. Values - This point included the concern that because science is male-dominated and societies ascribed different values to males and females, the values associated with women are largely missing from the present practice of science and technology.

It was suggested that the inclusion of more women in scientific and technological areas might both represent the more "humane" values and change the direction of science. This latter assumption was challenged in two ways: the women attracted into science may not possess "humane" values, and we may not agree on which values are desirable.

Other points raised were that women should be enabled to respond to national economic needs and demands and that the recruitment of more women into science would support those already working there.

2. Implications for practice

There was some discussion as to whether we should attempt first to change science before encouraging young women to choose it. Some questioned why women should want to do science. Others argued that if women opted out there would be no "critical mass" to effect change. It was agreed that early educational experiences were important.

Primary or Elementary Education

At the primary level problems arose from the inadequate science preparation of teachers. It was agreed that inappropriate teaching disadvantages pupils, especially girls who may not have out-of-school science experiences. Support for practising teachers through in-service programmes and subsequent support networks was recommended. In addition, the group concurred that major reforms in initial or pre-service education for new entrants, which address the inadequacy of preparation in both scientific/technological knowledge and in understanding of science processes. At the elementary level, science experiences should foster curiosity and enquiry, be related to the everyday experiences of children and find expression in art, drama, creative writing, and neighbourhood studies. The methodology used in teacher education should be a model for teaching practices in the classroom.

Secondary Education

At some time during the secondary stage of education, choice is introduced in the study of science; many were concerned that this choice should be delayed for as long as possible, but again the question of "why study what you don't enjoy or see the need for?" was raised. An answer seemed to lie in the presentation of science and especially of physics which was seen as boring and difficult. There was general agreement that the teaching of science should be related to young people's prior experiences and feelings and that social implications should form an integral part of it. The question of appropriate assessment was raised, and it was agreed that written tests were limited. Other techniques such as oral reporting, drama presentations, case-studies and journal writing were discussed and were recommended.

Tertiary Education

Discussants agreed that tertiary institutions should mount active recruitment initiatives to attract young women into science and engineering programs. Networks among female students should be established and any sexual harassment should be challenged and eliminated. The discussion concluded that re-entry programmes and access courses were needed to enable adult women to enter science and technology. The establishment of women's networks and the use of women-only tuition groups and, especially, women tutors were recommended.

Women Entering the Workforce

It was agreed that women must have access to all scientific and technological careers but that to change women's personal and professional lifestyles would require a re-examination of established norms and values. The group mentioned the danger of creating "Super-Women" by enticing women into several roles - mother, scientist, partner, and worker. It was concluded that male dominated paradigms of work, organisation, and achievement should be challenged for the benefit of all.

General Points

Both groups mentioned the need to continue to challenge and change the limiting, stereotyped expectations of young women, held by themselves, their teachers and significant others. Methods to achieve this goal include making existing women scientists and technologists more visible; media channels should be mobilised for this.

3/4. Technology and women

Various common points were made in answer to questions relating to the development of beneficial technologies and relating to a critical attitude about technological developments. They included:

- the importance of cooperative action across [illegible];
- the inclusion of critical assessment of technology in education at all levels;
- the development of consciousness-raising and pressure groups within the community.

5. Technology and Third-World women

Across groups, the following considerations were considered important to bear in mind in supporting women in the context of development of technology in the Third World.

(i) Different cultural values and traditions exist in the Third World and the West. Aspects of western culture might take a paternalistic, patronising view, either imposing technology for gain or withholding because of a romanticised, disillusioned view of technology as corrupting.

(ii) It was important to consult local needs in aid evolution of technology rather than the imposition of it. Women and girls with education and training could be targeted for assistance since they carry a heavy economic and manual burden, and their skills might be devalued when technology becomes sophisticated and men take over.

For example, women cultivate the fields, but men go to agricultural college.

(iii) One goal of Third-World education was learning for self-reliance. This goal involved two aspects: preparation of high-level and flexible technologists and establishment of appropriate technology in rural areas.

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[illegible] that [illegible] women [illegible] traditional [illegible] pushing them to [illegible] and ways of men and thereby [illegible] them to the status of men". This raises the issue of women's nature and whether it is and has to be different from that of science". Nowhere is gender culture more easily seen perhaps than in the areas of women's work and role models.

Sunee Klainin, Peter Fensham and Leo West (Thailand, 2/87) in describing the pre-eminence of women in the physical sciences in

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Thailand, have pointed out that not only are the majority of chemistry teachers female but the practice of chemistry is perceived as an extension of the activities associated with the kitchen and cooking. This, in Thailand, is 'woman's work' which helps to explain why in Thai chemistry classes the girls do all the work and the boys stand back and watch, which is the reverse of what occurs in the West.

'Gender Culture', the Girls and Mathematics Research Unit of the University of London Institute of Education reminds us, cannot be seen in isolation from class. (U.K. 3/79) Working class girls, they point out, desire mobility in class terms via education but not in gender terms. They also suggest that race may be an important variable.

In their study it was reported that none of the middle class girls wanted careers which involved 'helping people' and hence more of them opted for careers involving maths and science than did the working class girls. Their paper extends this idea by reflecting upon the big girl/baby girl dichotomy amongst working class girls and the necessity for their completion of domestic chores as distinct from middle class girls for whom domestic labour was minimal and in whom intellectualisation was encouraged.

What are scientists like

When Richard Simpson and Ann Birdham (U.K. 1/112) asked primary students to draw a scientist they found that 87% of the boys and 58% of the girls drew a male, usually old, with a beard, glasses and a white coat. Only 35% of the students drew a female scientist. They also found that 85% of the boys and only 27% of the girls would like to be a scientist when they grew up.

Gunn Imsen's research with 15-17 year olds (Norway, 3/103) showed that they perceived research biologists as open, exciting, helpful, articulate, democratic and considerate, while physicists were egotistical, boring, authoritarian and inconsiderate. How closely do these mirror reality? This was not addressed directly in submitted papers but two contributors have used the Myers-Briggs Type inventory to assess personality types. Barbara Simpson (U.S.A. 2/121) tested practising scientists and found subjects associated with different type variables (except for the extravert-introvert dimension). Similar associations were found in their college freshmen counterparts. In John Head's (U.K. 1/183) survey, male high school scientists fitted the type predicted by Myers, but the female scientists formed a distinct group which did not conform to the predicted type.

H Szydlowski and G Dudziak's investigation of physical science staff members of universities in Pozan. (Poland, 1/127) found that more men than women saw their work as a life-time objective, were more interested in following the latest developments, had the attitude that men were better science students, expressed an interest in a supervisory role, and spent more time than women helping co-workers and being creative.

One bright note comes from the work of Berit Skog (Norway, 1/117*who showed that while non-traditional girls chose science and gave more weight to careers, this was not done at the expense of social motives but, rather, added to them.

Participation and Performance

Berit Skog (Norway, 1/114) showed that girls who studied physics performed better in science than other girls, but that many bright girls chose not to continue with physics. This under-representation in science, particularly physics, has also been commented upon by a number of other workers, including Tamir (Israel, 1/135), Shadia Tel and Mohammad Subbarini (Jordan, 1/150), Marangu (Kenya, 2/113), Mary Trowbridge (Kenya 1/184), Karin Beyer and Jette Reich (Denmark 1/53), Anne Jorunn Berg and Elin Kvande (2/70) for the Nordic countries in general.

An additional worrying feature comes from Marsha Lakes Matyas (U.S.A. 3/112) who shows that in the USA when women do proceed to study science or engineering in higher education they have a lower persistence rate.

Evidence of interaction between context and performance emerges from a number of studies. Eve Humrich (U.S.A. 1/75) draws on the Second International Science Study to compare student performance in the USA and Japan. Males outperformed females in both countries but the scores of Japanese females equalled those of US males in some areas, including in physics. Males outperformed females also in Tamir's study (Israel, 1/135). Only Klainin et al found females equalled males in overall performance in physics and surpassed them in chemistry.

When contextual factors are examined further differentiation is reported. In the Thai study Klainin et al found that in some areas of chemistry females from girls' schools outperformed males and females from coeducational schools. Marlene Hamilton (West Indies, 1/70) also found greater success among girls for those educated separately, but their performance relative to boys was subject dependent.

Shadia Tel and Mohammad Subbarini (1/150) investigated interaction with the sex of the instructor. Effects were found for physics and chemistry but not for biology. A female instructor gave students a better grounding in chemistry and made the subject seem less hard.

Marsha Lakes Matyas (U.S.A. 3/112) claimed that undergraduate women science students were more likely to proceed to a higher degree and to display greater career developments if they had a female role model or mentor.

Attitudes and Understanding

The prior experiences of students shape, and are reflected in, the attitudes they display to science and technology.

Richard Simpson and Ann Girdham (U.K. 1/112) describe improving attitudes to science in primary schools in the United Kingdom with increasing numbers of primary teachers trained in science. But the situation of technology studies is quite different, with the common perception being that "technology is dirty, heavy work undertaken in male dominated situations".

Falco de Klerk Wolters, Jan Raat and Marc de Vries (The Netherlands, 1/87) found in their Dutch study of Pupils' Attitudes Towards Technology that technology was associated with products and not processes. Designing, inventing and creativity were not regarded as part of technology, unlike computors, domestic appliances, aeroplanes, spacecraft and robots.

These attitudes may explain why computors are readily becoming male sterotyped. As Morwenna Griffiths and Margaret Alfrey (U.K., 3/89) reported on the situation in English primary schools, 'the process leading to computers being part of a man's world seems well established. The next generation of teachers is likely, therefore, to be less open minded than the present one'.

Hannelore Faulstich-Weiland (Federal German Republic, 2/57) found an almost unanimous interest in computers among girls in the 8th grade in two West German comprehensive schools. Although having fun with the computers was of great importance to the girls, an assumption that an ability to use computers would be necessary for a good job later was more decisive in forming their interest. The boys in the study, however, consistently rejected the girls' right and ability to use the computers. The boys worked in a very different way to the girls, often disturbing each other by acting competitively rather than helping each other. Wieslaw Stawinski (Poland, 2/123) found that girls and boys seem to think differently in understanding ecology. Pinchas Tamir (Israel, 1/139) reports that girls prefer the type of enquiry experiences used in school biology classes as a mode of learning, but that although 'girls are more devoted students' spending more time on homework, concentrating more and seeking more help, 'boys perceive themselves as higher achievers in both science and mathematics'.

Levin, Sabar and Libman (Israel, 2/104) highlight the problem of 'affective readiness' for girls studying science. They found the highest correlate for achievement for both boys and girls was the students' self image as a science learner. In a similar mathematical study girls were found to perform much worse than boys on estimation tasks which Levin, Libman ans Shorek (Israel, 2/95) attributed to 'their lack of self confidence, lack of motivation and a high level of learning helplessness which then reflects on their strong commitment to traditional and familiar learning experiences'.

Tan Boon Tee (Malaysia, 2/129) found that 'girls tend to adopt a simplistic view of physical and natural phenomena more readily than boys'. These 'alternative frameworks' are very persistent and resist change by normal teaching methods.

Karin Beyer and Jette Reich (Denmark, 1/53) found both male and female students were more highly motivated by a curriculum organised around themes, but still had great difficulty explaining everyday phenomena using physical concepts. Girls tended to take the total problem in its realistic context more seriously than boys, being less likely to curtail their interest in the context and extra information, and 'play the game' of solving the intended physics component than boys.
Beyer and Reich point out that many physics concepts have quite

different meanings from the equivalent concepts used every day. The effective learning of such precise science concepts does not take place by simple assimilation but it requires the student to live through a crisis of learning which allows a reorganisation of cognitive structure (accommodation). The feeling of insecurity generated by this process of accommodation are responded to more positively by boys. In seeking security, girls rely on rote learning. Girls desire a thorough understanding of one subject before they feel comfortable attempting a new subject When girls told teachers, parents and friends that they did not understand physics, this was accepted and expected, reinforcing the girls' own belief rather than encouraging their persistence.

In-school/Out-of-school Experiences

Girls begin their study of science with a different experimental background to boys.

Gaalen Erickson and Sandra Farkas (Canada, 2/49) investigated the prior experiences that male and female students drew upon in attempting to answer a series of multiple choice science questions. Items were selected in which male students had performed at least 10% better than female students through the province. They found students frequently referred to a wide range of experiences when they were asked to explain how they arrived at their responses, but female students tended to rely much more on appeal to school-based experiences than did boys who had greater scope of experiences to draw upon.

The same study found girls were more likely to make particular errors in answering multiple choice questions than boys.

Sharon Parsons-Chatman (Canada, 1/97) points out that students' prior experiences includes not only a cognitive dimension but also affective and psychomotor dimensions. She suggests that tinkering is a process by which we intuitively make sense of the world at a commonsense level. Following in-depth interviews and classroom observations she conceptualizes tinkering at abstract as well as at concrete levels. Males tinker at both levels, but females tinker more at abstract than at the concrete level in the physical sciences.

In the light of these studies which indicate that girls are disadvanged by not adequately drawing upon their out-of-school experiences in understanding science, the work of Mette Vedelsby and her colleagues (Denmark, 1/171) seems very important. A special effort is made at the start of every theme and throughout to encourage students to establish a connection between the conceptions of everyday life and the science concepts learnt at school. As Sussanne Blegaa and Jette Reich report of the same project (Denmark, 2/34) the use of themes can encourage connections between observable phenomena or experiences and science subject matter.

Lore Hoffman (West Germany, 2/95) found that out-of school experiences shape interest and aspirations in physics and technology. She argues, however, that the type of teaching encountered by the student will also have particular significance in the formation of science interests. She isolates the climate of instruction as well as the content, contexts and activities of instruction as being important in developing as interest in physics.

Michal Kollan (Israel, 2/88) also found that appropriate in-school experiences were able to overcome the significant differences in prior experiences of girls enrolled in building trade studies.

The in-school experiences of many girls, however, are not so positive. Heidy Wienekamp, Walter Jansen, Hilke Fickentrerichs and Renate Peper (Federal German Republic, 2/137) observed over 80 chemistry sessions in West Germany and found boys were called upon to contribute to the class significantly more frequently than girls. Boys were more often encouraged to continue speaking, given praise more often and disciplined more frequently. On average, they found, the boys expressed themselves spontaneously twice as often as girls.

Sharon Haggerty (Canada, 1/62) also found that boys participated proportionally twice as often as girls in classroom dialogue. They asked questions proportionally more than four times as often as girls. The questions girls did ask were usually concerned either about the right answers to questions, or the accuracy of their experimental data, aspects which concerned them more than participating in classroom discussions. This approach, however, seemed to foster only a shallow knowledge of the science presented and did not lead to success.

Mette Vedelsby (Denmark, 1/171) emphasises the importance of the climate of teaching to effective learning. In addition to ensuring that the physics teaching room is a pleasant and inviting place to be she encourages discussions of both affective and cognitive aspects of learning and uses them as starting points for teaching.

She has adopted a style of confluent pedogogy where affective and cognitive aspects of learning flow towards the same goal. By teaching students to be aware of their own feelings, anxiety and alienation are minimised and a relaxed atmosphere is established. Her approach would typically begin with students listening silently to music, then writing down their own prior experiences about the topic, especially every day experiences. This validates both prior understanding and feelings, and emphasises students out-of-school experiences. Students share their experiences with a small group and ultimately the whole class in discussions which help to establish connections between the concepts of science and everyday life.

Implicatons for Future Teaching

1. Prior Experiences

Girls should be encouraged to consider their out-of-school experiences as valid learning and draw on them in the classroom. Opportunities should be provided, according to Marsha Lakes Matyas, (U.S.A. 2/12) to extend girls experiences with extracurricular science activities and interactions with science role models.

2. The Climate of Instruction

The climate of instruction was consistently identified as important, for both boys and girls. According to Lore Hoffmann (Federal German Republic, 1/45) there is a close connection between their interest and how comfortable they feel in the classroom, how well the teacher arouses their curiosity and how prepared the teacher is to answer questions. She emphasizes the importance of introducing a new topic in a way which includes an outline of work to come, makes connections between the topic and the students' prior experiences and also allows the use of student experiments.

Learning new things requires personal courage, self confidence and a willingness to take risks. Mette Vedelsby (Denmark, 1/171) advocates making the learning situation as non-threatening as possible by decorating the classroom and socialising with the students.

Gunn Imsen (Norway, 2/103) recommends showing students the social aspect of science: that engineers must co-operate with one another, travel and meet people; that computer work means listening to others and helping them to solve problems; and, most importantly, that technology is a way of solving human problems and not just a product or an end to itself.

3. Modes of Instruction

Heidi Wienekamp et al (Federal German Republic, 2/137) report that both girls and boys are very interested in practical work.

Girls in Pinchas Tamir's study (Israel, 1/139) were adamant that lectures were not the most effective way to teach physics and that the laboratory is indispensable in teaching physics.

Since women demonstrate less self-confidence and perseverance with science learning, Beyer and Reich (Denmark, 1/53) advocate teaching students to understand their own learning. Students should be aware that concept assimilation is a general process. Teachers need to introduce new concepts more slowly and reward partial as well as complete mastery. Female students, especially, need to experience success. The physical sciences should not be presented as allowing only either total mastery or total failure.

4. Valuing the Affective Domain

To help students acknowledge their feelings about their learning Vedelsby (Denmark, 1/171) advocates students keeping a record of their thoughts, feelings and reactions as new formulae, topics or experiments are encountered. She also stresses the importance of getting students to evaluate each theme completed (and then acting on students comments).

More girls may be encouraged to study science and technology if, in addition to other changes to curriculum and teaching style, the affective dimension of learning science is valued in the classroom.

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All summaries were prepared by Dr. Jan Harding using notes by the student reporters.

RESEARCH (Empirical/Quantitative)

Questions for Discussion

1. How can, or to what extent should, the strategies used to increase the number of women in science take into account both imperatives of gender and class?
2. How realistic are students' perceptions of scientists? Can and should these be altered? How?
3. How can we increase girls awareness of the process associated with their own learning?
4. How can we encourage female students to draw on out-of-school experiences as well as those which are school-based in order to maximise "real" learning?

Summary of Discussions

1. Gender & Class

It was recognised that effective strategies to increase the number of women in science must take into account the cultural context of the target groups. This context includes social class or status as well as racial/ethnic origins and assumes great importance in societies with a number of ethnic groups. Role models should possess similar characteristics to those of target groups.

Some questioned the goals or outcomes of science education and suggested that they needed modifying because they were unachievable by all students and they might be unacceptable to some political ideologies.

2. Perception of Scientists

It was suggested that children's ideas of scientists are culled from TV, comic, and textbook presentations which include stereotypes of the balding, bespectacled male, who is absent-minded or slightly mad. They are established early. Some groups pondered what children's drawings of doctors would look like and if young people had a conception of what a scientist's job entails. More and better TV shows were suggested in order to provide a more realistic picture of all kinds of men and women doing science-related activities. Likewise, schools should facilitate student and scientist meetings.

3. Processes of Learning

Discussion in one group focused on the variety of learning styles possible in science and stressed the need to diversify the learning environment to accommodate all students. A related issue was the need to train teachers to meet that need. Another group recommended that the processes of science should be emphasised rather than content which assumed too prominent a place and encouraged rote-learning. Both groups rejected single-sex teaching groups as a model and recommended attention to cognitive stages of student development.

Another group speculated on some of the research in the area of learning processes, asking if it were possible to capitalise on girls' greater openness in asking questions as well as to integrate everyday examples into formal learning of science.

Recommendations for future action included cross-cultural studies on psychological constructs such as "mindfullness" and field independence, although the reservations that Head voices (I/183) were not raised.

4. Out-of-School Experiences

Two chief factors emerged from discussions concerning this question. First, girls out-of-school experiences were not perceived as being science related. It was noted that more could be done to illustrate science related experiences and to legitimise those experiences. Second, more extensive science-related experiences could be made available to girls through science clubs, miniservice camps, etc. in which girls were encouraged to participate by teachers, parents and organising bodies.

Target groups that could benefit from increased awareness of gender issues were identified as parents, teachers, counselors, museum staff, corporations, toy companies, media.

SYNTHESIS OF CONTRIBUTIONS: EXPERIMENTAL AND QUALITATIVE RESEARCH

Leonie J. Rennie
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(Australia)

Margaret S. Gremli
Institute of Southeast Asian Studies
(Singapore)

If one word could collectively characterize the papers submitted for the experimental and qualitative sections of the contributions to the GASAT 4 conference, the word would have to be none other than that which represents the overall theme of the conference itself: DIVERSITY.

The eighteen papers were diverse in terms of origin - eleven countries were represented; in terms of focus - ranging from train sets for Christmas to the professional experiences of women engineers; and in terms of subjects - sample sizes ranged from several to seventeen hundred! But all of these papers made an important contribution to a growing body of knowledge that embodies the richness of opportunities, the wealth of disciplines and the diversity of cultures which GASAT represents. Given this diversity and all the limitations that are inherent in the preparation of a synthesis paper, our hope is that in synthesizing this set of papers we have not compromised that diversity and the potential it holds for understanding more about women's participation in science and technology.

A Framework for Discussion

The framework we chose for our synthesis is chronological. We thought it would be useful to examine the various stages of metamorphosis (if you will) of a cohort of female students moving from early out-of-school experiences, through school-based experiences towards the more advanced stages of schooling where specialization occurs. We have linked this specialized level of science studies with the concept of career orientation and thereafter incorporated papers which relate the experiences of women scientists in their workplace. In our perusal of the papers, we have tried to tease out recurring issues and, where appropriate, draw attention to other contributed papers outside of our designated sections.

Diversity in Early/Out-of-School Experiences

One of the eighteen papers dealt directly with the link between student's early experiences and subsequent achievement in science. From England, Kelly reports analyses of data collected as part of the GIST study. Tinkering, biological and theoretical science scales were developed from an activities questionaire administered to about 1,700 eleven-year-old children early in secondary school. Kelly found low correlations between scores on the scales and choice of, and achievement in, biology, chemistry, physics and technical craft three years later. When a composite measure was used to partial out the background effect, the correlations were found to be trivial and mostly not reaching significance.

In a related paper, Rennie described a study which followed a cohort of 342 twelve-year-old students through their first year of secondary school. Participation in a range of out-of-school activities was positively correlated with students' affect and their achievement in science. But, like Kelly's study, participation in out-of-school activities was an insignificant predictor of achievement in comparison with students' attitudes and perceptions about school science. Both researchers viewed their findings optimistically for, according to these studies, prior experience is not necessarily a hindrance to girls' achievement in science. Even so, Kelly expresses the belief that girls' relative inexperience in science is still an educational problem that must be taken into account in schooling.

Staberg's paper offers qualitative data from Sweden which complement the quantitative findings of Kelly and Rennie. Staberg is following 32 thirteen-year-old students through grades seven to nine when they will make the subject choices that will determine their career path. This study is now at the half-way mark and data from interviews and classroom observations support the notion that girls are not disadvantaged by their early inexperience with certain types of toys. By being better at following instructions and good at laboratory work, girls' disadvantages were outweighed by their advantages - they were able to compensate for the boys' enhanced knowledge of objects and technical vocabulary. Staberg suggests that girls may do better in the long term if science and technology related subjects were introduced earlier before girls become preoccupied with their growing maturity.

Diversity in School-Based Experiences

The notion of changing the point at which science is introduced and how it is taught in school, rather than changing the behavior of female students to adjust to existing methods, was a concern voiced at GASAT 3. Yet, two years later, it remains a goal easier to set than to accomplish. In her qualitative research, Elkjaer focuses on an alternative way of teaching computer science to 8th and 9th grade classes in Denmark. Elkjaer argues that social and cultural issues need to be included in technical studies so as to maximize the interest of the girls. But, in observing the class of one of the two cooperating female teachers who were willing to change their teaching in this way, Elkjaer's preliminary results indicate that boys reacted negatively to the new approach and disrupted the discussions of social implications of technology that the girls seemed to enjoy.

Boys were also reported as dominating classroom discourse in an Israeli study. Sabar and Levin studied classroom interactions of a group of very capable eleventh grade students who participated in a special biology research class that involved students in authentic scientific research. In this program, students spent one full day per week in a research laboratory but, back in the classroom setting, classroom discourse for boys and girls differed markedly. Out of 75% of the total classroom utterances recorded for boys, half of these involved answering questions posed by the teacher. Yet of the 25% of all utterances recorded for girls, 75% were requests for further clarification of concepts. Test scores showed that even though boys evaluated themselves higher on comprehension and class activity than their female counterparts, the more overt participation and apparent confidence of boys was in no way indicative of greater comprehension on their part. Interestingly enough, the teacher seemed unaware that girls were less

The tendency of girls to seek help in understanding their work is also highlighted by Burns and Bird. Working with 45 sixteen-year-old (twelfth grader) students in New Zealand these researchers focused on students' perceptions of their understanding in chemistry. They found girls more willing to ask for help than boys. Girls' tendency to solicit help from teachers, family and friends was linked both with their stated goal to "learn as much as possible" and with their high level of task-involvement. In contrast, Burns & Bird link the tendency of boys to work alone and their [illegible] with [illegible] involvement. [illegible] reduction [illegible] cooperati[illegible] for girl[illegible] centered [illegible]

Kahl[illegible] Australia[illegible] and girls [illegible] relations[illegible] whereas, [illegible] them bein[illegible] the inter[illegible] pattern h[illegible] well int[illegible] boys. By treating the boys as equals and the girls as "different" this teacher reinforced the idea of science as a masculine pursuit. This assertion was borne out by the subject choices made by the students from his class who went on to study science in the subsequent year. Students followed the stereotypical pattern of a tendency of girls to take biology classes while boys opted for physics and chemistry.

Similar differential treatment was noted by Alting and Pas from the Netherlands. As part of the NEXT project, the authors report on teacher differences in their treatment of boys and girls in technical-vocational education for sixteen- to twenty-year-olds. In this study, interview and questionnaire data from 100 teachers and students from 10 different schools reflect an opinion that females receive more favourable treatment than males. Half of the students reported that female students received more attention than male students and a third that they got this attention sooner. Only 2% of students thought that boys received more attention. Data from teachers themselves concurred with student data. Aside from interactions associated with the academic curriculum, teachers also reacted preferentially to the social behaviour of female class members. Disruptions from females were more likely to be ignored or to attract a verbal denial whereas boys were more likely to receive punishment. Whilst female students acknowledged and even disapproved of the status quo, many of them seemed resigned to it as part of social norms.

Differential treatment received by girls in classes described by Kahle and Alting and Pas would inevitably perpetuate the gap between the way girls and boys experience science as a discipline. In turn, these differences in experience may diminish girls' independence and self-confidence in science studies.

One way of enhancing young women's confidence in their science studies is suggested in the paper by [illegible], who suggests the use of analogies as a means of promoting learning. The self-professed lack of self-confidence in females was evident in [illegible] preservice teachers who were subjects of this study conducted in the USA. In a pretest these females stated that they preferred to wait for directions rather than initiate their own activity, despite suggestions in the third person that the student's role was expected to be active and independent. This [illegible] was [illegible] by the end of the [illegible] study period in an experimental group who were exposed to a [illegible] technique [illegible] development of [illegible] concepts. Besides demonstrating significant improvement in [illegible] creativity, it appears that [illegible] students to [illegible] teachers [illegible] teaching.

Level of perceived difficulty was a problem investigated by Randall with a group of [illegible] students' [illegible] of [illegible] subject [illegible] attention to the [illegible] of [illegible] Randall argues that since males and females do not differ [illegible] perceptions of the difficulty of physics [illegible] don't encourage more females to take it. Finding that male subjects had higher opinions of their own ability than female subjects, Randall draws on attribution theory to suggest that females need special help to develop the necessary self-confidence to tackle what they perceive as 'difficult' subjects.

Subject Specialization and Career Orientation

Self-confidence and success in reaching higher level courses in science are being investigated in a study of unpopularity of physics among girls in the Netherlands. Born, Kuhlemeier, & Van in't Veld in their longitudinal study have taken both a quantitative and qualitative approach to a study of why physics is an unpopular examination subject for girls. From the results obtained from questionnaires to 122 classes of thirteen-year-old students, the researchers discovered that although girls' interest in physics waned after only two months into the basic course, they were still just as motivated as their male peers. Further data will indicate whether the motivation of the boys and girls in this group will separate out over time during this two year course and what proportion of girls continue with more advanced courses.

The in-depth interviews carried out in the qualitative part of the same study affirm what we have known for some time: that role models are influential in orienting girls to their future careers. What also seems logical is that girls themselves report that their opportunity to continue in more advanced science courses is determined by factors partly beyond their control such as examination grades, evaluation of their work and parental and teacher advice. In contrast, these factors would also enter into boys' decisions to continue in physics but perhaps, with boys, interest has less precedence over examination grades especially in [illegible]. In their study of [illegible] students, [illegible] report instances of boys [illegible] examination grades as [illegible] evidence of their [illegible] understanding. Further information will [illegible] as the [illegible] study continues to monitor the [illegible] factors in girls' subject choices.

The thrust of the preceding papers seems to suggest that discriminatory treatment of girls in encouraging them to pursue advanced science courses and subsequently science careers, however subtle, must surely be linked with girls' perceived competence in science and play their part in the career choices of girls. [illegible] Singapore [illegible] engineering [illegible]

Although [illegible] in all of the other countries represented in this section of the proceedings [illegible] light of this, what do the papers in this section tell us about what influences this status quo? In other words, is there a consensus on what affects the decision of large numbers of qualified young women to avoid entering science related careers? The question is a simple one to ask but a complex one to answer.

Two British researchers, Carter & Kirkup, reporting on their interviews with women engineers in the UK and the USA, reveal that there is a tendency for young women, even before they are seriously considering marriage, to take into account the multiple roles they will assume in the event that they marry and have children. Relating their experiences in their own institution, Carter & Kirkup admit that they felt at a loss in advising some young women who were struggling with these kinds of career decisions. Apparently, the young women in question sought advice on how they could achieve a balance between potential family commitments and anticipated job demands. It may be of interest to find out whether such concerns enter into the decisions that male engineers make about their future career paths.

Another paper by [illegible] and [illegible] addressed this question of balancing career and family roles. They reported that graduating Finnish female engineering students who are at the beginning of their career path shy away from thinking about the dual demands of a professional career and the equally demanding task of raising children. Sadly, most of the young women they talked to held the opinion that it would be 'almost impossible' to have both an interesting job and raise children. As these two researchers explain, it was as if their subjects had to adopt a male identity in order to fit into their chosen profession. Understandably, [illegible] and [illegible] voiced their concern, fearing that these young women engineers might end up 'belonging neither to a woman's world nor to a man's world'. [illegible] study of Austrian women working in a metal craft factory reveals a similar dichotomy of conflict between the professional and gender identity of the skilled women in their study. Most of these women reported that they would be forced to give up their jobs after they had opted for having a child. [illegible] laments that it was as if 'the very same qualities which mean recognition and success at work seem to threaten their femininity'.

The factors which influence the potential professional identity of young women are not only intrapersonal; they are also linked with the structure and content of the academic programs that prepare students for a career in the applied sciences. This brings us to examine the nature of the curriculum itself and the impact it may have in orientating female students to a career in science and technology. Several papers had something to say about this. There seems to be a consensus that, as far as the applied sciences are concerned (particularly engineering) the curriculum must be altered if it is to be of relevance to the interests of young women. In a broader sense, the social implications of applied science applications must become an integral part of the curriculum if the full potential of women's contributions to technology is to be realized.

Van Dyne and Kemble are of the opinion that the engineering curriculum at their institution in the [illegible] interest in the humanities. [illegible] study of the implications of new technologies for third world cultures.

In a similar vein, Kolmos identifies four elements - technique, competence, organisation and production - which, she argues, are basic to an analysis and assessment of technology; this provides a theoretical base for her argument that technology as a whole must change to incorporate a more appropriate balance of male and female values. She reports that her institution in Aalborg, Denmark has already made headway in changing the engineering curriculum. Here an analysis and assessment of social issues is incorporated into the first year of the engineering program. She reminds us: 'There will be a gap if women enter into male-dominated areas without bringing along their values'.

Women in the Workplace

The meaning of Kolmos's words and the sentiments expressed in other papers become even more lucid as we move now into looking at implications of increased participation of women in traditionally male-dominated working environments, and here there may be some cause for concern. We use the word 'concern' advisedly and avoid use of the term 'problem' so as to dismiss the implication that problems are caused by women entering typically male-dominated fields. What is a more appropriate way of looking at it, in our view, is that neither women nor the nature of the workplace is the 'cause' of the problem but that there simply is, at present, an incorrect fit between women scientists and engineers and the environment in which they carry out their chosen profession.

What kinds of alterations may be necessary to create a better fit and, more importantly, to maximize the unique contribution that women can make? The first involves, curiously enough, women's interactions with their female co-workers. We learn from [illegible] and [illegible] that women engineers have difficulty asserting their authority over other women who are subordinates. A similar finding is evident in [illegible]'s study. Here women are forced to compromise their higher status in order to match the identity of their less skilled female co-workers before they are able to fit into the existing workplace culture.

With reference to 'workplace culture', mention should be made here of the study of Kvande and Rasmussen whose paper was not placed in this section of the contributions. But findings reported by these researchers are crucial to our discussion of women and the way in which a better fit can be obtained between existing workplace cultures and the values brought along by an influx of women. Kvande and Rasmussen make their point by referring to research on women's management styles. Women managers operate differently in the workplace; they emphasize social skills and cooperative behavior among their co-workers and they delegate responsibility as a preferred managerial style. This contrasts with the managerial style of men which is characterized by incisiveness, ability to set goals and make decisions, and assertiveness. At opposite ends of the spectrum, males' preference for static roles and womens' preference for dynamism are likely to cause conflict unless they are properly understood and discussed in the open.

Moving away from the workplace and into the home, we see that, likewise, much discussion and compromise must occur before a sufficient degree of change comes to the household. Change must occur in the home so that the responsibilities of caregiver and home manager are eventually shared equally between the partners in a marriage. If this is not possible, normal household budgeting must include childcare and housekeeping support for full-time working women. Then, if this is simply not affordable (even at the expense of other luxuries) then the responsibility for child care arrangements must fall elsewhere, perhaps on the shoulders of the employer. To illustrate what a difference adequate child care makes, witness the peace of mind cited in the Carter & Kirkup study of the woman engineer who went assuredly to work leaving her child in the capable hands of a nanny.

Concluding Remarks

In our role as discussants at this GASAT 4 conference we undertook the task of providing a synthesis of papers that were classified under the experimental and qualitative research section of the contributions. When writing this paper, we encountered diversity in every possible sense. Moreover, the richness inherent in this diversity was further enhanced by the fact that these two approaches to research reinforce and complement each other.

While each study was conducted in the context of its own social and cultural milieu, we found that as we deliberated over the papers, any sense of parochialism disappeared. Rather, we found themes which persisted across studies. One common theme pertained to the consistent pattern of gender-related differences in girls' and boys' experiences both in school and out of school. A second theme was the reluctance of girls to take a leading role in classroom discourse which seemed to stem from their lower levels of self-confidence in science studies. Yet another theme was the diversity of educational and career opportunities presently open to young women and the choices that evolve from this. A fourth theme was the long-term holistic approach to career decision-making apparent in young women in the process of making crucial decisions about their future.

We found it an interesting and enlightening experience to work through the papers in our section and then, in reading papers submitted to other sections, find that the four themes we identified were recognizable to a greater or lesser extent throughout. But then, in all honesty, we concede to the fact that the themes do nothing to enlarge upon those that were already recurrent in GASAT 3. In other words, we are fully aware of where the problems lie, but we do not yet seem to be giving enough of our attention to how we can move on.

For instance, we know that as they progress chronologically through their education, girls in school and maturing young women struggle with successive conflicts of interest. In the classroom, girls struggle unknowingly with teachers and teaching methods which often reinforce rather than weaken patterns of gender difference. In the curriculum they struggle to reconcile social and technical aspects of the science disciplines. Similarly, they feel obligated to balance the demands of future domestic and career responsibilities. Moreover, if they reach the status of a fully-fledged professional "engineer", they are not engineers in the stereotypical sense, they are female engineers. So, once again, women must struggle with the social expectations of their families, their peers, their colleagues and workmates and even with their own identity as they attempt to fit their desire for job satisfaction with their need to integrate into the workplace culture.

It is therefore disappointing that now in GASAT 4 it is still not clear in which direction we must move to resolve these conflicts. Unilateral attempts to change the people, the places or the pedagogy have brought little progress. Perhaps we should ask not who or what should change to achieve a better fit between girls and their classrooms and between women and their workplace. Rather, we should ask how we can best arrive at a kind of mutual adaptation of women adjusting to what has been a traditionally male-oriented career and a workplace culture that needs to absorb women both with their special circumstances and for the special contribution they can offer to science and technology.

From the natural sciences we have learned that changes occur in species as a result of their successful adaptation to changing or new environments. We also know that neither change nor adaptation could take place without the diversity that is characteristic of all living forms. In the interests of the survival of all that we value, let us ensure that now we have fully explored the diversity of problems that exist for girls in science and technology, we can capture the potential of this knowledge to move forward in directions that will truly bring the results we are all committed to.

All summaries were prepared by Dr. Jan Harding using notes by the student reporters.

RESEARCH (Qualitative)

Questions for Discussion

1. Do we have a sufficient data base to move toward resolving the problems and conflicts experienced by girls and women?
2. If not, what further research is required?
3. If so, what steps should be taken to implement theory?

Participants chose to join groups focusing on the following different areas.

A. Early Socialisation and Out-of-School Experiences

It was agreed that a considerable amount of data was available but that two problems associated with the issue persist. First, issues are researched in a piece-meal fashion, and contextual factors are not always controlled or reported (e.g. the socio-political context. And, second, existing data may be influenced by a white Anglo-Saxon cultural context and, therefore, the findings cannot be extrapolated to other, different cultures.

It was suggested that we did not yet understand how differential early socialisation might result in different cognitive styles or the problems which some women may experience working within a paradigm which historically had been defined by males.

B. Classroom Experiences

It was felt in each of the two groups discussing in this area that factors such as self-concept or self-confidence had not been sufficiently researched. One group felt that more research was needed in a number of areas, e.g., motivation, attitudes, out-of-school experiences, assessment, classroom interactive patterns and teaching styles as well as more work was needed in the follow-up of intervention programs, the optimal age to teach certain concepts and the way gender, class, and race affect the way science is learned. Recommendations from research included enabling students themselves to challenge stereotypes; involving teachers in sex-equity research and development work so that they possess and identify with it; using supportive teachers to move the reluctant teachers. Research producing contradictory results should be scrutinised and replicated to identify sources of contradictions.

C. Subject Specialisation & Career Orientation

One group agreed that comparative research seemed to show that a later choice within the sciences led to a less sex-differentiated outcome. Therefore, if objectives for science education include achieving greater sex-equity as well as providing a broader base for scientific literacy, then a core science curriculum for all students would more likely meet those objectives. It was agreed that girls should be enabled to make a realistic assessment of women's life-patterns and of the labour market before being allowed to close doors by choosing not to pursue certain studies. Research had shown the importance of mentors in attracting young women into science-related careers and of networks in retaining them there.

Since girls seem to choose subjects for interest, it was recommended that science should be presented to them in a way in which they felt comfortable and by which they recognised science/technology's relevance to their interests and needs.

One group acknowledged the extent of the data base that was accumulating but suggested that much more attention should be directed toward the interpretation of those data.

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EVALUATION

Yael Rom

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Existing Situations and Specific Programs

This paper will try to give an analysis and a synthesis of 31 individual papers dealing with the evaluation of existing and specific programs, so classified by GASAT 4 editors.

Analysis started with tabulations of the articles by subjects, status and affiliation of authors, methodology and impact and countries of origin, followed by analysis of contents within subdivisions.

The findings show an interesting pattern, best described as a spiralling pattern (Figure 1):

1. Growing awareness of the issue at hand will usually start a general evaluation attempt or a local research program.

2. Evaluation of research projects or local situations will trigger an intervention program.

3. Evaluation of intervention programs, their conclusions and recommendations, and evaluation of local situations may lead to the formation of government, or local, policy for implementation.

4. Evaluation of the implementation of the newly defined government policies will trigger more awareness, more research, more intervention programs etc., etc..

The dynamics of change, in our case a change geared to produce more girls in science and technology, have been dealt with by several authors. Eunice Ukeke, from Nigeria, states that the start off line is when the distinction is made, and felt, between awareness and concern. Jan Harding, from England, describes her four stage model: Dissatisfaction - Acceptability - Relevance - Feasibility, and paces her implementation efforts accordingly.

Social and educational changes have different paces in different countries and societies. The state of the art in different countries is presented by the focus of subject matter in the articles for GASAT 4, (Table 1).

FIGURE 1 THE GASAT PROBLEM: SPIRALLING GROWTH

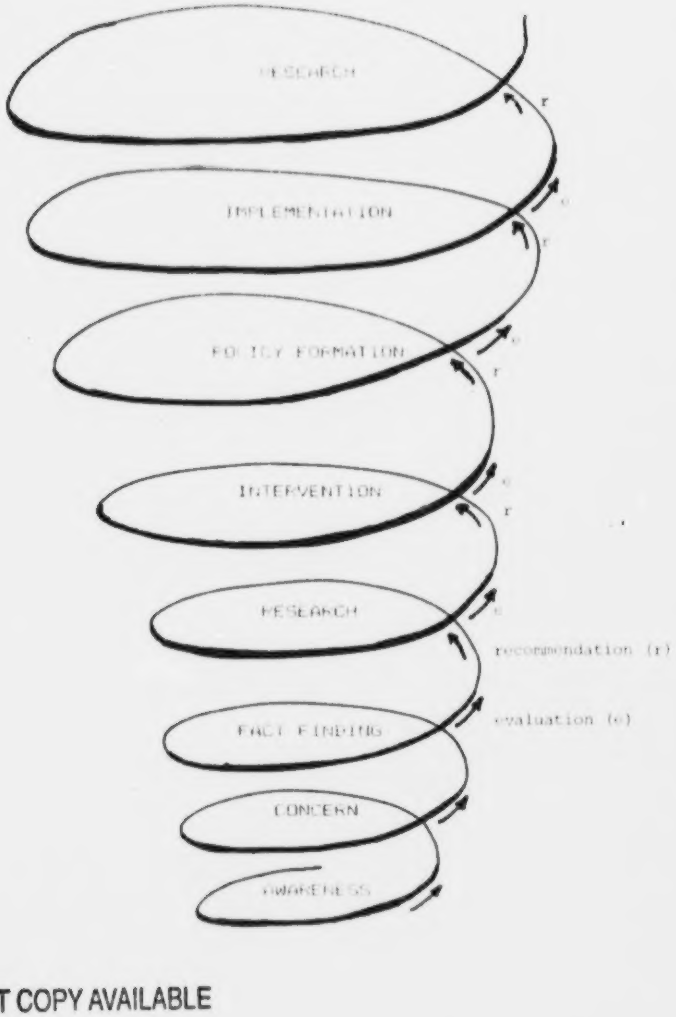
RESEARCH
r
IMPLEMENTATION
e
r
POLICY FORMATION
e
r
INTERVENTION
e
r
RESEARCH
e
recommendation (r)
FACT FINDING
evaluation (e)
CONCERN
AWARENESS

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Table 1 GASAT 4 papers classified by subject focus and country

	Total	Evaluation	Research	Intervention
U S A	22	5	7	10
U. K.	15	4	6	2
Australia	13	9	3	1
Denmark	11	2	5	4
Netherlands	9	4	4	1
Canada	8	3	4	1
Israel	9	3	5	1
	86	33	34	20

The articles to be discussed can be further subdivided as follows:

a. Evaluations of the national or regional system of education revelant to the issue at hand - and suggestions to modify or ameliorate the situation in order to increase output. (9 art.)

b. Evaluations of existing situations by lobbyist organisations and their suggestions for ways and means to increase outputs. (5art.)

c. Evaluation of curricula and curricula change. (6 articles).

d. Evaluation of computer studies programs. (4 articles).

e. Evaluations of other subjects. (5 articles).

A. Evalutaions of national or regional systems of education

Nine writers evaluate national or regional systems of education and recommend a variety of measures and models geared to increase the number of girls in science and technology.

Although the statistics are totally different - Australia, Kenya, Sweden, Israel, the UK and an UN agency - analysis of the situation and "first aid" recommendations are very similar.

The underlying assumption is that if only the girls knew more and better the personal benefits of science studies they would all sign up for science majors. Most of the recommendations focus, therefore, on programs for the dissemination of information and on models for work on attitude change among candidates and their significant others.

There are differences between the six countries both in the philosophy underlying the educational system and in the availability of science studies, the different levels of education and the percentages of girls studying science at each level. Yet there is at least one common conclusion and recommendation:

> the educational system should make all pupils study science thus ensuring actualisation of equal opportunity for "FUTURE GIRLS" , the girls best prepared for optimal options of career choice and job placement.

The underlying assumption leading to this recommendation has been that when left to make their own decisions most girls will not choose science majors and the few that do will probably choose life sciences and avoid physical sciences.

None of the articles report actual implementation of a national policy to register girls in science majors. Several articles report achieving a national agreement and even allocations, with last minute aborts of programs, the reason given quite blunt.. no money .
All articles except two deal with the issue as a feminist issue and demand equality of educational opportunities as a basic

Asenath Sigot, from Kenya, laments the waste of natural human potential: Kenya's women, the real economic force in the country, have not as yet had the opportunity to assume jobs and roles which need prerequisites in science & engineering or technology.

Yael Kom, Israel, presents another aspect, that of a national need for human resources development, a national need for better trained and highly qualified persons. Providing the availability of these much-needed persons among girls and women and the feasibility of their upgrading, she argues, will eventually make government allocations more accessible.

There is a special problem which I think should be further examined and which we should try to resolve:

A popular recommendation calls on governments to intervene by providing a mandatory requirement for all people to study science. This means WE ask government to FORCE girls to register in science classes for their own future good, a good of which they are still unaware but which we SELF-NOMINATED LEADERS OF A CAUSE have chosen for them. These placemants are, for the time being at least, somewhat against their own inclinations and frequently also against the favoured expectations of their significant others.

This line of action is contrary to the philosophy of most lobbies fighting for human rights and equal opportunities, especially the feminist lobbies. In most countries, and for most causes, this means fighting to curb government interventions and controls.

B. Evaluation by Lobby Organisations

Five writers - UK, Nigeria, Canada, USA - have written about evaluations of programs or recommendations for change and they are very characteristic of lobbyist organisations:

The papers deal with evaluation of government efforts to lead change. The papers are:

1. criticising the program as insufficient or overlooking a major problem, such as access to computers as predictor for future choices

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2. evaluating the program and presenting crucial feedback to the government agency in order to rectify and improve the program; in the process the lobby assumes a legitimate-formal supportive role

3. initiating their own program and actually running it, hoping that government will eventually take over.

What we actually have here is a full spectrum of lobby activities starting with the classical promotion of legislation, moving into promotion of friendly regulations and better allocations of resources, and growing into actual participation and responsibility for formal programs. The dynamics of change here are of extreme importance:

> Government (national or local) is actually calling on a minority group , in the sense of its not being adequately represented in the decision making process, to do what would be best for the group and provides government funding to do so'

For countries who do not have a sympathic minister of education or minister of finance, the development or growth of the active lobbies into sharing participants is very encouraging.

C. Evaluations of curricular change

Six writers - Australia, The Netherlands, Finland - deal with curricula, but only two of them evaluate actual changes in teaching methods and new write-ups of texts.

There is a tendency among writers in this subdivision to attribute girls' avoidance of the physical sciences to their association with destruction. (Bearlin, Australia). Therefore, they say, if we want girls to enroll in physical sciences our efforts should be directed towards the humanisation of these sciences.

By bringing into the classroom simple everyday phenomena and explaining them through physics, chemistry and mathematics, by relating science to the human body, to historical development, to the organisation of society and the professional world - there is hope to overcome the alienation of youngsters, to cut the associative link with armaments and the abuse of ecology.

Raat and de Leeuw evaluate 7 new programs for teaching physics in a friendly environment in The Netherlands, and Widdup from Australia discusses Math-anxiety levels by gender and SES, introducing the concepts - "narrow coding" and "broad coding" - to explain anxiety growth.

D. Evaluation of computer studies' programs.

Four writers - Germany, UK, USA, - evaluate computer studies at various age groups and different levels of education - junior high, technical school, undergraduates and adults. Despite the variety in country, educational system and age group, conclusions are similar:

Girls are less enthusiastic than boys about computer studies and will sign up for courses only if it is a requirement.

Once they are in the class and studying they tend to be less active, more cautious towards shortcut innovations, angry when boys show them how to.

However, they tend to achieve higher grades in examinations, even higher than boys who have pre-academic experience in computers. Yet, despite higher achievements in freshman year attitude-change towards computer studies occurs only in 3rd year courses.

Of special interest are the implications of these findings for any effort to muster more girls into engineering programs.

Armstrong, Lepold and Linden, of Purdue, suggest that the rather small increases of women enrollment in engineering in the 1980's, as compared to the ten-fold increases in the 1970's, can be attributed to the changes in the engineering and technology curricula and in the criteria of the Accreditation Board for Engineering and Technology (ABET). These now include computer based courses and credits as required part of the ABET-accredited college engineering programs.

So, since women perform exceptionally well in academic computer courses despite their pre-college inexperience, their recommendation is to publicise widely their success in order to unlock this apparent barrier.

E. Evaluation of the relevance of women's work

Four papers - Canada, England, Norway and Sweden - deal in various aspects of women's work and their relevance either to career choices among high school girls or to growing dependency of much career development on prerequisits in science and technology.

Two of the articles enlarge on the classical debate as to whether change should start at opening up non-traditional job opportunities and only then filter down to the school system to be used for vocational guidance and counselling, or whether the educational system should encourage youngsters, especially girls, to study science and technology in order to be better prepared for future career options.

Limited job opportunities in rural areas extinguishes expectations of change: "what is the good of learning something I will not be able to use anyway". On the other hand, if schools will prepare youngsters only for available jobs the outcome will be self-segregated classes. Under such constraints the conclusions of Israelsson from Sweden and Whyte of England are to work on attitude change among their significant others, especially teachers and parents, who tend to be conservative and non appreciative of girls' abilities to acquire technological skills.

Tremblay from Canada and Kvande and Rasmussen from Norway, deal with women in management and the impact of new technologies on career developments, in-service training and up-grading. They elaborate on the importance of the structure of the organisation and see dynamic organisation as more friendly and facilitating than static organisation, for the growth of women managers.

c. Evaluation of other subjects

Three papers - Canada, England and Spain - deal with very specific subjects: psychological types in science careers, co-educational vis-a-vis girls only classes, and a bibliometric study of an on-line database (2300 items) on women in Scholarship, Engineering, Science and Technology, called WISEST.

Bertram and Crawley from Alberta, Canada, have actually prepared an inventory of statistical bibliography and by putting this on the computer enable the production of lists of data elements in desired sequences that can be easily counted and tabulated. The main findings of this study are:

> "The literature of women in science has been shown to be very diverse with an emphasis on articles from journals and an increasing emphasis on analytics from monographs (often conference papers). This is usually interpreted as being characteristic of a newer, less established field which has not yet developed a core literature of its own."

The effect of GASAT conferences is impressive, practically multiplying its own items each conference.

Summary and Personal Notes

Awareness of the scarcity of girls in science and technology studies and employment has grown all over the world, but concern for remedial policies and their implementation are still the responsibility of small groups and private persons.

In many countries, we the concerned, are working and making progress - but not enough and not at a national scale. In too many countries the issue is still perceived as a feminist issue and therefore does not get high priorities when national allocations are being discussed and divided.

Evidence shows clearly that women and girls are very good students and have good academic preparedness for college and pre-college science studies. Efforts should therefore be made to accumulate data that can prove to governments that the best national investment is in human resources development, especially in encouraging girls and women to actualise their latent talents and apply themselves to areas and subjects they have shunned until now.

Should lobby groups manage to convince governments about the feasibility of investing more, or at least equally, in science education for girls, lobbies should insist that even outreach programs be conducted with national funding while the lobbies share be restricted to setting up support networks for pupils and students and their significant others. It is my evaluation

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[illegible] qualified personnel national policy will more readily adopt this line of thought.

The problem I find most important for discussion is that of the conflict between the freedom to choose and the recommendation to force girls to study science for their future good!

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EVALUATION

Mona Dahms.

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SECTION 1: DESCRIPTIONS/CASE STUDIES

Introduction

In this section nine papers, representing four different countries, are presented. Two papers, in the contributionas classified under Theories and History, have been included in this synthesis, because the contents of the papers fitted here better than in other synthesis.

The first part will describe the effects of legal measures of intervention in China and in Australia. In the second part organizational measures are analysed and in the third part other types of measures are being described. Finally the main points will be summarized.

Legal Measures

In old China, ie. China before 1949, women's status was poor, as it is described in the papers by Zhou Meihe (1/251) and Jinpei Zhang (1/259). They were bound by the three obediences (to father, husband and son) and the 'four virtues' (morality, proper speech, modest manner and diligent work). They had no rights and only seldom had the opportunity to get education, job or salary. "Most of them ran around stoves for the whole of their life". This sad situation has changed with the constitution of New China, which emphasized women's equal rights in politics, economy, and social family life. Girls equal rights to education are guaranteed by law. Chong Feng Jiong (3/279) described government sponsored special programs for girls in schools and in extra-curricular activities. Thus "Love Science" activities, math contests and microcomputer contests for girls are among the extra curricular activities undertaken by the Shanghai Association of Science and Technology. Girls perform very well in these activities and also in science subjects in school.

Zhou Meihe reported a dramatic increase in the number of women workers, from 7.5% to 36.7% in the total workforce, and women now formed one third of all technicians, research scientists and engineers. She reported the success of women scientists in many fields, while Jinpai Zhang referred specifically to chemistry. In the Institute of Elemento-Organic Chemistry, 6% of all staff, 50% of the professors and 45% of the lecturers are women.

Xi Qian (1/250) reported that women constitute about one third of the workforce in environmental engineering where they have made positive contributions and are to be found in high positions; she is a professor in environmental engineering herself.

Although women are an [illegible] modernization of China problems of equal rights and status still prevail. The rate of female to male scientists and technicians is still 1:2.1; for engineers it is 1:4.4 and for senior engineers 1:7.5. Discriminatory procedures are still encountered in factories and schools, and in the family many women still have to do most of the household work alone. To overcome these problems it is necessary to speed up social progress and to encourage women to struggle for self improvement of their qualities and abilities.

Another example of the positive effect of legal measures comes from South Australia. Here a Girls in Science Task Group was formed in 1984 as a curriculum committee within the Education Department, with a female to male ratio of 3:1.

Goals are to inform, influence, communicate and support all measures of research and development on this issue, at all levels. Tasks undertaken by the group so far include the preparation of a position paper, establishing a resource library and a register of school based projects, and the setting up of an area network of interested teachers.

A state conference is planned to present the position paper, with support papers and to establish more area network groups.

Organisational measures

The positive effect of organisational measures is illustrated in the case study on CSIRO - Commonwealth Scientific and Industrial Research Organisation - described by Carmel MacPherson (3/246) from Australia.

In this organisation, which is the largest employer of scientists in Australia, a high level of discrimination was reported in 1984. Therefore a systematic Equal Opportunity Program was launched. Its implementation has resulted in a 60% increase in the number of women scientists. However, female enrolment is made difficult by the lack of female applicants for scientific vacancies.

Therefore CSIRO also has launched a program called Women in Science, aimed at encouraging girls in year 10 of high school to continue with science and mathematics courses.

Once employed by CSIRO a major problem is a clear imbalance of tenure in favour of men throughout the organisation, and stereotyped attitudes of "appropriate" female jobs still exist. While the Equal Employment Opportunity program has had some success, there is a continuing need to monitor employment practices.

From Israel comes a study of career patterns of Ph.D. women at the Weizmann Institute of Science by Hadassa Horn (3/237) All these women were to be found in biology or chemistry related disciplines; none were affiliated to physics or mathematics.

Rigid rules governing the pace of promotion, through which those failing to comply left the Institute, resulted in little difference between women and men scientists remaining, but fewer women than men in senior positions. Women and men did not differ in average age for receiving a Ph.D., their productivity was comparable and there were no salary discrepancies within the same academic rank. Unlike reports from US studies, senior women were well-integrated into the scientific community (although many had young children) and they rejected suggestions that they would follow they husbands should they move to a different city.

Other measures

Carita Peltonen (Finland, 2/222) describes a labour market with a strong female participation, but also with a strong sex polarization. This situation influences young persons in their choice of career. Thus only 5.4% of girls and 0.7% of boys at age 18 plan to choose a profession dominated by the opposite sex.

When choosing a career the individual is influenced by psychological as well as social factors. Girls choosing a career in science and technology seem to have self-confidence and self-esteem similar to boys planning such a career. Thus to enable more women to enter science and technology, structural changes must be made.

Changes suggested are:

- science and technology subjects should be taught in kindergarten.

- sex biased subjects of all kinds should be made compulsory to both girls and boys.

- networks and support groups of girls in science and technology education should be formed.

- parental leave should be shared equally between women and men.

Conclusion

As the above examples have shown, legal and organisational measures can have a certain positive effect in changing the general picture of the under-representation of girls and women in science and technology. But - as it also shows - the problem is not solved just by introducing laws, rigid rules or equity programs - attitudes existing in society on the stereotyped roles of women and men must also be changed. Therefore structural changes are needed and awareness-raising measures are necessary.

SECTION C THEORIES AND HISTORY

Introduction

In this section six papers, representing six different countries, are presented. Two papers, originally classified in this area in the contributions, have been included in the synthesis of description/case studies instead of here.

In the first part, influence of the image of science on girls choice of subjects and careers is discussed. In the second part history is called upon, not only to identify role models, but also to explain cases of underrepresentation. The third part discusses differences between male and female ways of thinking, to find explanations of the drop out of women from scientific research. The final section summarises the main points and raises important questions.

The Image of Science

Science is male dominated and therefore affected in its contents - the questions asked and answers found. Ann Hibner Koblitz (USA 1/276) ascribes this point of view to "radical feminists" and criticizes it as being too general, stereotyping science and scientists and not paying attention to the diversity of scientific workstyle, nor to the existence of imagination, intuition and creativity as important elements of all scientific endeavour.
The paper warns against advocating the idea of science as masculine and therefore antifeminine. Instead of encouraging young women to take up studies of science and to plan scientific careers, one might risk scaring them away from the field by reinforcing stereotypes of science as alien to girls.

Anne Walton (UK 2/143) expands on the "Storybook Image of Science" which is based on two main tenets: emotional neutrality and objectivity. The traditional image of a scientist as an independent, reticent male, rather cold and unsociable, more interested in things than people, goes hand in hand with the story book image of science. This prevailing image of science and scientists is of course disasterous to young girls considering a scientific career, as Koblitz warns, but the scientists themselves are to blame, at least partly. Most practising scientists have been raised on the myth of objectivity and the belief of being devoid of emotions. Even today, in spite of abundant evidence of the opposite, a core of male scientists, who conform to the traditional image of a scientist, believe in the myth.

On the other hand, Walton claims, there are many scientists, who do not conform to the traditional image. Among these scientists we find the majority of women, and characteristic of many women scientists is that they have gone through a maturation process, moving from belief in the myth of objectivity and emotional neutrality towards a human-orientated social awareness, which is reflected in their work. These form useful role models for girls.

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A Historical View

The use of women scientists as role models is also recommended by Sylvia Berckert (Sweden, 2/235). She instances Mary Somerville, born in Scotland 1780, who wrote many books on science subjects and was called the Queen of the Nineteenth Century Science, and Lisa Meitner, who was born in Vienna in 1878. The latter received a doctorate in physics in 1905 and became assistant to professor Max Plank in 1912. She discovered the fission reaction in 1938, but did not - contrary to her male colleagues - want to participate in the work on the nuclar bomb, hoping that it would prove impossible.

Thus we could use history to draw attention to women scientists. Equally important is to draw attention to ordinary women as a historical group, as pointed out by Candida Martinez Lopez (Spain 3/287): "We start from the premise that the teaching of History plays a crucial role in establishing concepts such as how and why the forms of domination, submission, systems of power and their evolutuion exist and decide who their main protogonists have been".

History teaching at Spanish universities excludes women as a group mainly because, in the view of male researchers, they contributed nothing to history. The lack of reliable resources is often quoted as justifying the absence of women but, again it is a matter of bias of the researcher, not looking for the historical facts and details concerning women.

Analysing the history of Victorian England may help us find explanations to the persisting disproportion of women in science, as pointed out by Ann Howard (Australia, 3/271), who shows how science, in the form of phrenology, was used to "prove" women were inferior.

Is there a difference?

Differences between women and men is also the theme of Renee Hable (The Netherlands 3/260). There seems to be a gender based difference in the way of handling a complex problem. The female way is to define the problem in its complexity by taking time to look for all aspects, whereas the male way is to reduce the problem as quickly as possible to a part-problem, taking into consideration only one aspect of the complexity.

"Female thinking" comes up against three obstacles:
- there is no time for lengthy observations,
- it arouses uncertainty, seemingly more straining to men than to women,
- complexity cannot be delt with by limited formal scientific language, but needs switching from one language to another, an ability which women seem to have more than men.

When women experience these obstacles they may lose confidence in their female thinking, whereas the problem really lies in the inability of men to handle the uncertainty and complexity in the female way of approaching problems. One aspect of this complexity is the possibility of recognizing certain aspects of one object in another object, while still retaining the perception of difference as being essential. Now this recognition does not stop with the perceived object but includes the subject and the question arises: can there be partial recognition of the knowing subject in the to-be-known object. In other words: is science not objective after all?

Discussion

Before I go into the discussion of this last section of papers I would like to make two points clear.

The first point is that I am a feminist and feminism is the lens I use when analyzing the questions of women in science and technology.

The second point I would like to make clear is that when I am using the words female/male or feminine/masculine I am thinking of gender as a social construction - not as biological sex.

And now to the discussion:

The question raised by Renee Hablet "Is science objective" leads right back to Anne Walton's "storybook image of science" with science based on the two tenets: objectivity and emotional neutrality.

These two basic tenets link with the basic image of science. Undoubtedly, the prevailing image of science in general is one of science as masculine and dominated in form as well as contents by male virtues. This stereotype picture of science does not do full justice to the existing diversity of scientific workstyles nor to the female values actually present in scientific endeavour. It is, however, the picture adhered to by most people and also by the girls we want to address. Therefore I think it is very important that we try to go back in history, not only to look for female role models, but - more important - to try to analyse and understand how and why science came to be the way it is today, closely linked to power and control and excluding women as a group. This in my opinoin is what some of the radical feminists are attempting, and I do not think that you do justice to these women by saying that they reinforce dualistic stereotypes. To illustrate this point, let me end my discussion by quoting a few sentences from the book "Reflections on Gender and Science", by Evelyn Fox Keller, who - by the way happens to be on the Advisory Committee for this conference.

"...the aim of these essays is more exacting: it is the reclamation, from within science, of science as a human instead of a masculine project..."

My version of gender-free science is not a juxtaposition or complementarity male and female perspectives, nor is it the substitution of one form of parochiality for another. Rather, it is premised on a transformation of the very categories of male and female, and correspondingly, of mind and nature".

(Epilogue p.178)

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All summaries were prepared by Dr. Jan Harding using notes by the student reporters.

EVALUATION

Questions for discussion

1. Is there a conflict between freedom of choice and the recommendation to make science studies mandatory for all?
2. Pesonality inventory tests are used for both vocational counselling and placements. Should we research and implement findings in our strategies to attract certain girls and women into science and technology?
3. How do we break the cycle of the stereotyped image of science attracting certain personality types, who then reinforce the stereotype?
4. How do we combine legal, organisational, and other measures to achieve the goals of GASAT?
5. Can historical research help us in the goals of GASAT? If so, how?

Summary of Discussions

1. Choice or compulsary?

Discussion recognised the dilemma and revealed cross-cultural differences. Factors influencing approaches to this question included: availability of skilled personnel in relation to job opportunities and desired outcomes of science education (whether to produce highly trained specialists or a flexible and inventive population). It was suggested that compulsary science/technology education might not lead to greater participation unless the image (nature) of science presented at different stages of education was altered to be more gender-inclusive at each stage. In addition, more and better trained teachers would be required.

2. Personality Inventory Tests (PITs)

Discussion showed participants had reservations about PITs: both their reliability and stability of outcomes were questioned. Moreover, the qualities deemed to be important in the pursuit of engineering and science might be too narrow and sex-role stereotyped, with disadvantages to females. One group noted that there was some evidence that good female students were quitting engineering for reasons other than academic ability.

3. Stereotyped Image

The use of personality type was criticised in one group as being too simplistic, since people change and personality is expressed through a variety of characteristics. It was apparent that further discussion of research to establish shared meanings was necessary.

The concept "image of science" also came under discussion. Some felt that if science's popular image did not change, many women might not choose to be involved in its pursuit. The powerful influence of media was assumed in a proposal to monitor and analyze, over a period of time, the way science was projected in TV programmes in order to make representations to programme directors.

The position of the woman scientist was considered. Criticism of the values of science were likely to make her feel criticised and alienated. Much more sympathetic dialogue and mutual education was needed. Women physical scientists were suggested as credible agents of the changes promulgated by GASAT.

4. Combinations of Measures

The group first discussed the goals of GASAT. Various questions were raised. For example, one aim was to attract more girls into science, but was GASAT concerned with women in science? What happens to science when more women practice in it? Perhaps, an important goal would be to encourage more women to enter governmental positions in order to spread our goals across the power structure. It was important, some felt, to include men within the lobby. Others were concerned that men would dominate discussions, and they suspected male motives for being involved. It was emphasised that membership in any mixed sex group should be open and flexible with each side willing to listen to and consider conflicting views.

5. History

Two areas of historical research were identified: one specific to women's studies with a focus on women, and one on the development of science to include women. The following points were made:

(i) Bias is difficult to avoid in writing history;

(ii) Women's history has low status;

(iii) We need to know how science devalues women's work within it.

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GASAT Volunteer Workshops & Special Interest Sessions

by
Jane Butler Kahle

Many people, concerned about the issues involving girls and science and engineering, requested an opportunity to present a workshop session. All requests were honored with the warning that our busy schedule would mean that workshops would be concurrent sessions. In addition, many participants requested time for special interest sessions after they arrived in Ann Arbor. As time and space allowed, many were organized. Some of the workshops/interest sessions were:

Research Interests and Techniques	Jacquelynne Eccles & Judith Meece
Computer Equity	Jo Sanders
Technology for Life on Earth	Sue Lewis Marian Lowe Anne-Mette Kruse Margaret Bearlin Alejandra Leon-Castella
Physics Teaching & Girls	Sussanne Blegaa Karin Beyer Helene Sorenson Mette Vedelsby
Engineering & Girls	Mary Anderson Yael Rom Jane Daniels
Student-Teacher Interactions	Heide Weinekamp
COMETS	Walter Smith
Norwegian Science Project	Anna Lea

All workshop presenters were invited to submit papers. The Norwegian Science Project submitted one and it follows. The list of GASAT Networks and Working Groups which may be found at the end of this volume is partially the result of these informal, and highly productive, sessions.

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THE PRIMARY SCIENCE PROJECT IN NORWAY

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INTRODUCTION

The University of Oslo has a long tradition in studying the issues involving science education and gender issues related to science education. The Primary Science Project draws on this background beginning with the "Girls in Science" project (Lie and Sjøberg, 1984), the GASAT conference held in Norway (1983), and most recently the National Version of the Second International Science Study (Sjøberg, 1986). A recent study on the current crisis in recruitment of teachers to science teaching also serves as a basis for the project (Horsfjord, 1986).

The Primary Science Project began in the fall of 1986 with the goals of improving the quality of science at the primary level through classroom research and curriculum development. Classroom research serves as the basis for a clear understanding of the changes that are possible in today's schools. Development of curriculum materials is based on the current demands and needs of the primary teacher and pupil.

1. Science at the Primary Level

Norway is one of the Scandinavian countries in the northern part of Europe with a population of 4.1 million people. Because of the geographic variety with the country, one may find schools ranging from one room schools up to large city schools with over one thousand pupils. See figure 1 for a summary of the Norwegian educational system.

In the primary school (grades 1-6) science is taught as a part of an integrated subject including social studies, geography and history. A national curriculum states that pupils in grades 1-3 shall spend 2 hours per week on this integrated subject out of a total of 17 hours, pupils in grades 4-6, 6 hours per week out of a total of 27 hours per week.

2. Why a Primary Science Project?

2.1. Student Attitudes Toward Science

A national version of the Second International Science Study conducted in 1984 clearly indicated that children begin as early as 4th grade (10 years old) to form attitudes about science and

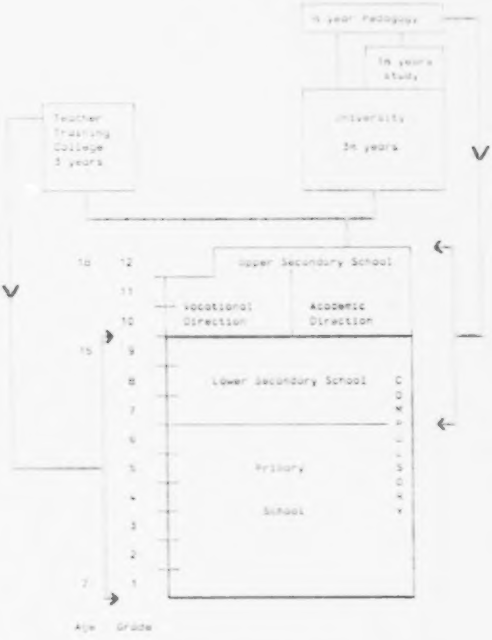
½ year Pedagogy
1½ years study
University
3½ years
Teacher Training College 3 years
Upper Secondary School
Vocational Direction
Academic Direction
Lower Secondary School
Primary School
COMPULSORY
18
15
7
12
11
10
9
8
7
6
5
4
3
2
1
Age
Grade

Figure 1. The School and Teacher Education System in Norway

scientists (Sjøberg, 1986). If we consider gender, girls have more of a tendency to form negative impressions of scientists and science than boys. The trend becomes even stronger as girls progress towards the upper secondary level.

2.2 Student Experiences in the Sciences

Girls and boys at the primary level come into the classroom with a different set of experiences (Sjøberg, 1986). The existing science curriculum often favors those experiences boys share while failing to build on typical girl activities. This clearly puts young girls at a disadvantage and may be responsible for creating negative impressions toward science.

Early intervention is needed to create a more positive science learning environment for **all** pupils. This can be accomplished by including more "girl-friendly" examples in curriculum materials and by giving girls the opportunity to share in those activities that are typically boy dominated. A well designed curriculum should include enough variety to encorage participation by all types of pupils so that science can be both challenging and fun for everyone.

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2.3. Primary Teachers

Teachers at the primary level have little to no formal science education and yet are expected to teach science topics. Teachers often lack confidence in their ability to teach science when they themselves are not able to answer questions and understand basic concepts. The result is that science is often a neglected part of the elementary curriculum.

An overwhelming majority of all primary teachers in Norway are women, making the problems associated with primary science also problems associated with gender. Women, more than men, tend to underrate their own abilities in science performance resulting in fewer women studying the sciences, and fewer female primary teachers teaching science topics.

2.4. The Need For Science in Our Schools

It is clear that science and technology are playing an important role in today's society and that schools must take an active role in preparing pupils to participate in that development. Providing positive science experiences at the primary level is necessary if we are to promote scientific literacy as well as encourage more children to seek eventual careers in the sciences.

3. The Primary Science Project in Norway

The primary science project began in the fall of 1986 with the goals of producing and evaluating curriculum materials for grades 4-6 and conducting research on the primary science classroom. The project is funded through the Department of Education, with additional funding from the Committee on Gender Equality, and the University of Oslo.

3.1. Curriculum Materials

Curriculum materials are developed in the form of topic workbooks which include pupil activities, a teacher's guide for each activity and a pupil reader. The target group of pupils is grades 4-6 (10-13 years old). Each topic workbook is designed with activities for 6-10 lessons.

Pupil Activity Worksheets - Developed to instruct pupils in the activity and provide stimulating questions and further activities. Pictorial information is included as an important component of the worksheet to aid in understanding. For most activities it is recommended that pupils work together in groups of 4-5.

Teacher's Guide - Each pupil activity worksheet has a corresponding guide that:

1) describes the activity.
2) provides ideas for methodologies on how to carry out the activity.
3) provides possible questions pupils may ask and answers to those questions.

4) provides just enough theory to put teachers in a learning situation together with their pupils, and
5) provides ideas and activities on how the lesson may be used in connection with other subject areas.

Pupil Reader - A short book, written for each topic, provides additional written information for pupils. Emphasis is placed on connecting the science activity to theory, history and everyday applications. When applicable, information is provided on careers within the scientific area. As with all materials, the pictorial materials pay pariticular attention to eliminating stereotypical gender role models.

3.2. Evaluation of Materials

Evaluation of the materials is conducted in two phases:

Phase 1 12 teachers from grades 4-6 from two local schools trial the materials in the first version. Two observers are present for the lessons with one observer taking notes and the other taking video recordings. Short, informal interviews with teachers follow the lessons.

Phase 2 Teachers throughout Norway are given the second version of the materials to use independently in their classrooms. Written evaluation forms for each lesson are provided for teacher comments. When possible a member from the research team visits the school during at least one of the lessons and informally talks with the participating teachers after the lesson.

After both phases of evaluation the research team makes revisions of the materials based on classroom trials and teacher interviews. Our experience to date is that revisions are extremely important and necessary. Each phase of the evaluation process provides new information from teachers and pupils that is then incorporated into a new revision. We can not overemphasize the importance of classroom trials in providing valuable information in the evaluation process.

3.3. Classroom Research

An important component of the primary science project is classroom research that will help to describe the primary environment. We are interested in describing the social interactions between pupils and teachers so that we can better understand what is necessary and what is possible for making a successful science lesson.

We are specifically looking at gender differences between pupils and teachers with reference to the science lesson. Our observations will hopefully guide us in the development of those methods most suitable for the primary science lesson. We need not only to involve young girls in scientific activities, we need to involve teachers in the teaching of science as well.

The use of video recordings during the science lesson has proven to be a rich source of information on social interactions between

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pupils and teachers. Video tapes give a permanent record of observations and are used together with written comments to record the events that occur during the science lesson. They also provide a means of external evaluation and validation when viewed by researchers external to the project.

4. What Have We Learned ?

We have used the first year of the three year project to develop a curriculum model for materials and to conduct extensive classroom observations. Our experiences and observations are constantly giving new insights into the primary classroom and helping us to determine what is possible for primary science. It is our hope that others working in the area of primary science will find the following comments both informative and perhaps generalizable to other situations.

4.1. Involving Teachers in Primary Science

The first requirement for implementing a successful primary science curriculum in Norway is to provide teachers with materials that give them the confidence and the willingness to "jump in and get their feet wet!" Too many teachers at this level have a fear of science due to their own lack of understanding, and think that primary science is too difficult to teach.

Our answer to this problem is to help the primary teacher redefine science at the primary level. Pupils at this level need science experiences more than facts. An activity based curriculum takes the teacher away from the authoritarian role and places them into the helper and learner role along with their pupils. In addition, we have designed a teacher's guide that helps the teacher every step of the way with ideas and answers.

The second requirement for a successful science curriculum is to provide teachers with support in their school environment. Our experience has shown that a **group** of teachers in a school will have more interest in teaching a new curriculum than a single teacher in a school.

The advantages of this group model are that teachers can work together in a joint effort and give each other support. After trying out activities they can discuss them with each other, share experiences and give new ideas. It is also an efficient use of time for the assembling of equipment. One teacher can be given the responsibility of gathering a classroom set of equipment that may then be used by other teachers teaching the curriculum.

The third requirement for a successful science curriculum is early intervention into teacher education. The introduction of a non-threatening science curriculum giving students experience with simple science concepts may give teachers just enough confidence to take an interest in the sciences once in their own classrooms. Our curriculum materials are being used at teacher training colleges to teach simple science topics and to demonstrate a method of writing interactive materials for the primary level.

In-service training is also an important area for increasing interest in teaching science topics. We are working on a model that involves groups of teachers from individual schools coming together to learn about our materials and methods. We believe that whenever possible, teachers should be given the opportunity to try out the materials themselves before presenting them to their pupils. Any experience with science outside the classroom provides teachers with an added amount of self confidence.

Our most positive sign to date with regards to overcoming the fears of teaching science is that the teachers we have been working with throughout the evaluation trials keep asking us for more materials. Once through a topic workbook they suddenly realize that they have successfully taught science and that they and their pupils have enjoyed it as well.

4.2. Gender Issues Related to Science Education

Our initial classroom observations were made with eyes toward gender behavior during the science lesson. We were interested in knowing whether teachers give girls and boys different kinds of attention, and whether children themselves have defined gender roles while participating in group work. We were also interested in observing whether gender differences among teachers influences teacher/pupil behaviors.

The following describes some of the most obvious observations we have observed with regards to gender:

- Boys is every studied class level receive more attention than girls. They raise their hands more often, were called on more often and were recognized for negative behavior more often than girls.

- Only a limited number of pupils answer all of the questions during a class discussion. The total number of boys answering questions usually is greater than the total number of girls answering questions in a classroom.

- When given free choice, pupils choose to work in single sex groups.

- Teachers of both sexes tend to give boys more attention overall during the lesson. They also encourage boys to find solutions to problems themselves while often physically showing girls how things are done.

- Girls more than boys seem to be bothered by noise and an unstructured classroom.

- Girls are more clever to complete written assignments than boys. Boys get going on the activity much quicker than girls and even make up additional experiments when finished with the assignment.

These observations have guided us in the development of methodologies that will encourage both girls and boys in science activities. We encourage teachers to begin lessons with some form of activity before a discussion with the class. This gives all pupils the opportunity to gain experience with the topic area and will allow everyone an equal chance to participate in sharing their experiences.

Group activity is encouraged in the curriculum materials even though our experience shows that the primary classroom has little experience with group work. Knowing that boys and girls have tendencies to work differently, we are constantly challenged to write materials that encourage all types of learning and social behaviors. If boys tend to take equipment first, then we need to make sure that there is enough for everyone. Should a group work together using equipment, we need to insure that enough tasks have been assigned to include all of the participants.

We are consciously choosing science topics and presentation methodologies that encourage both girls and boys to enjoy and participate in science lessons. Not every topic has an equal appeal to all pupils, but a well rounded curriculum will hopefully not exclude pupils either. A curriculum that provides varied experiences for all pupils is more desirable than one that draws only on those topics that certain groups are already good at.

Creating an environment that gives equal opportunities to girls and boys is not an easy task. Teachers and children enter the science classroom with different experiences that are often gender dependent and based on a long history of social behavior. We will be studying girl/boy interactions more thoroughly in the next years of the project and hope to begin to find some solutions to existing problems that may have an impact on improving science education for both girls and boys. An improvement in gender related issues in the sciences will hopefully be generalizable to other areas of the curriculum as well.

The Primary Science Project will continue to work over the next two years on the research and developmental issues relating to primary science in Norway. We would appreciate any comments on the project and are more than willing to share our further experiences.

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Final Banquet & International Talent Show

by
Jane Butler Kahle

One of the pleasant traditions of GASAT is its final banquet, which is followed by an evening of fun and sistership at the International Talent Show. The banquet was highlighted by our speaker, Betty Vetter, who provided the data and statistics which is the cornerstone of much of our work. Dr. Vetter's remarks enabled all participants to learn the most current demographics concerning entrance and retention of girls and women in scientific and technological fields. Her paper follows.

Chris Black, who was the mistress of ceremonies, provided the right mixture of gaiety and seriousness as she introduced performers from around the world. Most participants were members of a "troupe" from their home country. We rolled on the floor with the Danes' antics, our eyes misted as our Filipino representative sang, we cheered our favorite contestant during the Swedish skit, and we joined hands in song in conclusion. One of the "original" songs, presented by our friends "Down Under" follows as well as a collage of performers.

U.S. WOMEN IN SCIENCE: PROGRESS, PROBLEMS AND POSSIBILITIES

Betty M. Vetter

Presentation to International Conference on Women in Science
Ann Arbor, Michigan - July 26, 1987

American women have made remarkable inroads into the community of scientists, particularly over the past decade and a half. But they have not yet achieved equality, either in numbers or in opportunities, with men in these fields, and the problems they continue to encounter are formidable. Nonetheless, a number of activities are being put in place that promise some hope for continued advancement in the future.

I'd like to talk to you this evening about their progress, the problems still evident, and the possibilities for the future.

With some rare exceptions, American women are relative latecomers to science. A little review of earlier history shows us why. Women's colleges were the major source of science baccalaureate education for women in the late nineteenth century although some other public and private universities admitted women, both as undergraduates and as graduate students, and the numbers increased during the first two decades of the twentieth century. Although their representation in science was small, by the 1920s, women were earning substantial proportions of doctorates awarded in all the science fields, including 16% of those in the life sciences, 8% in the physical sciences, and 17% in the social sciences.

However, the steady increases in the numbers and proportion of women earning doctorates in science ended with the beginning of the great depression in 1929. There was a slight increase during World War II, while most of the men were busy elsewhere, but the proportion of women among new doctorated, as indeed among baccalaureate graduates, dropped abruptly beginning in the mid-1940s as veterans returned home, armed with the G.I. Bill, to fill the nation's colleges to overflowing.

Many educational opportunities for women were closed off in the post-war years. Higher admissions standards for women than for men were established to assure room for the returning veterans, and most of the best universities had quotas for women that eliminated even many of those who met the higher admissions standards. The proportion of women among new doctoral scientists dropped steadily, reaching a twentieth century low in the 1950s when women earned less than 4% of the doctorates awarded in the physical sciences, only 9% in the life sciences, and 11% in the social sciences.

The beginnings of the women's movement in the 1960s, coupled with a gradual understanding by girls and young women that they needed to prepare themselves for the world of work, brought increasing numbers of women into college and into science fields. From 1960 to 1985, women earned more than 56,000 doctorates in science, and an additional thousand in engineering. About two-thirds of these degrees were awarded after 1974. Women earned about 8% of science doctorates in 1960, 17% in 1974, and 27% in 1985. During this period, there was very little field shifting in the social and life sciences, and fewest in the physical sciences and engineering.

So there has been progress--an immense amount--particularly since 1970. For example:

- Qualified women may now attend almost every higher educational institution in the nation.
- Women now earn half of all bachelors and masters degrees awarded in the U.S. and more than a third of the doctorates.

- In science, women now earn 45% of the bachelors degrees, 39% of the masters degrees and 27% of the Ph.D.s.

- In addition, they now earn 31% of the M.D. degrees, up from 8% in 1970, and 29% of law degrees, up from 5% a decade and a half earlier.

- Finally, they have entered, and are staying in, the labor force, both before and after they have families.

But there are problems--most of which have not been solved. Armed with the appropriate educational credentials, women have been moving into the science labor force. But here, despite laws and executive orders requiring nondiscrimination, differential treatment of women and men has not disappeared, and equality of opportunity does not yet exist, even for students.

Some of these problems are economic--others are societal. All have a negative effect on the achievement of women in science.

These problems begin at birth. We not only label babies in hospital nurseries with appropriately pink or blue blankets, we continue to treat them differently throughout their childhood and school years. Little girls are still taught to be quiet and obedient, not to make waves, to be, as the folklore tell us, "sugar and spice, and everything nice." They are the nurturers and the homemakers, and the toys of their childhood largely reflect these functions. In school, boys are encouraged to question, praised for their outgoing, aggressive pursuit of superiority in school work, as in sports and life itself. Girls are labeled 'tomboys' for the same attributes, and as women, they are seen as 'pushy' and 'unfeminine' when they emulate the only role models they have at the top--men. They are told and shown over and over that men do not like competitive women, and that their chance for marriage and family may be lessened if they are high achievers at school. They are told by our society that they are less competent than boys; and that they have less mathematical ability than their brothers. Thus, when they run into problems in mathematics, a typical response from an elementary teacher or even a high school guidance counselor is, "It's alright, honey, I never could do math either." So many drop off, closing their options to a science career as early as the eighth grade.

They face other obstacles on the way to a novitiate in science. Women science graduate students are considerably less likely than men in the same field to have either institutional or federal support during their graduate study. They are more likely than men to be self-supporting. Women in physical sciences, mathematics, computer science or engineering are particularly likely to have to work with foreign teaching assistants and faculty--most of them from countries where cultural differences in the view of women and their place in society creates serious difficulties for American women. Not all American men treat women as colleagues--indeed, sexual harassment of women, though against the law both in academe and in the working word, is widely persistent.

After completing a doctorate or, in some instances, an appropriate lower degree, women find more difficulty in attaining a first position than do the men with whom they graduate. For the past fifteen years, biennial surveys of the doctoral population have continued to find that the unemployment rates of women doctoral scientists and engineers are two to five times higher than those of men. In 1985, for example, women were 17% of the doctoral labor force in science, but 35% of those who were involuntarily unemployed. Fortunately, the unemployment rate for doctoral scientists is considerably lower than other segments of the U.S. population.

Once they find a job, women are less likely than comparable men to find full-time work when that is their choice; less likely to find a job in their field; and less likely to find an academic job in the tenure track. This is not a function of their more recent entry into the labor force, since at least twice as high a proportion of women as of men employed in academic institutions are neither tenured nor on a tenure track, and this difference has not changed in the past decade.

Further, whatever employment sector they land in, they will be paid less than comparable men, and the gap in salaries which is present even in the first job, will widen with age. This is because women are less likely to be promoted; less likely to move into managerial responsibilities; and less likely to be given opportunity to work for advancement than their male colleagues.

The salary gap is important for women, not just because salaries in America represent achievement and power, but also because a women's salary allows her to buy some of her time. Even though she may be working full-time, American women are generally still responsible for the care of their children and for the upkeep of their homes. If her salary is sufficient, a woman can buy her time by hiring help and for the many tasks she is expected to do, whether it is child care or housework, meal preparation or even wardrobe selection.

Unfortunately, American women must accept lower salaries because they have no choice, but I think most of them hope they can raise them through hard work and accomplishment. It doesn't happen that way. For many years, many people of both sexes insisted that women's lower salaries were largely a function of their relatively recent entry into the profession. It was assumed that when we had data to correlate, not only salaries and field and degree level, but also years of experience and employment sector, that the differences would disappear. We now have the data, but the differences remain, and in some instances, increase. Women earn less than men in every field of science, at every degree level, and at every level of experience. The penalty for being female ranges from a few hundred dollars per year at the first job following a bachelor's degree to as much as $12,000 or more per year for doctoral women scientists after 20 to 30 years of work. In 1985, among doctoral scientists and engineers, the average salary difference is $10,500 per year--up from $9,100 in 1983 and $8,600 in 1981. Progress seems to be moving backward.

Another significant problem for American women in science is that their increases in participation have stopped, and in some cases, appear to be reversing. Not only is the size of our college age population starting downward, as it will continue to do through 1998, but the proportion of women within this smaller population who are choosing to major in science also is dropping. If this trend continues, it will have a seriously detrimental effect on America's ability to maintain international technological competitiveness over the next two decades. It also may negate the chance for women to reach critical mass within the science community. Although some continuing increases in the participation of women in science at the graduate level are probable, future increases are not assured, and some gains of the past decade may be lost.

There are, however, signs of change that offer possibilities for hope. Because the federal government is the employer of many scientists, both directly and indirectly through contracts it awards to industry, some concern has arisen in regard to the effective encouragement and utilization of women, minorities and the handicapped. A Federal Interagency Task Force, including membership from all Federal agencies, has been mandated by law to examine the current status of these groups in the federal government and in federally assisted research programs. The Task Force has held its first organizational meeting.

Various groups in American Foundations, in industry, and even in academic institutions, have started to realize that the need to encourage women and minorities to participate in science and engineering is no longer a matter of 'affirmative action', carried out as a moral responsibility, but is a matter of national survival. White males are a rapidly decreasing proportion of our American population, who no longer carry the total burden of responsibility for government, for research, and for the many other leadership posts which must be filled.

Finally, American women have amazing persistence in their battles toward equality of opportunity and recognition. After 1776, women worked for 144 years to obtain the right to vote, and for 187 years to get a law on the books requiring equal pay for equal work--a law not yet fully enforced. An amendment to our U.S. constitution that would provide equality under the law for women was first introduced in 1932. Although the Equal Rights Amendment has not yet become part of our constitution, it has only been 64 years since it was introduced, and we will keep trying.

- There are now 51 women members of the National Academy of Sciences--or 3.5% of total membership. Only 60 women have been elected to membership since the Academy's founding in 1863, but three of the new women in 1986 are women.

- Women now head, or have recently headed, several of the major scientific societies, including AAAS. The American Physical Society, the American Astronomical Society and the American Chemical Society.

- Two American women have received Nobel prizes in science in the past decade.

So there are hopeful signs, along with those that are not so hopeful. Together with women all over the world, American women will continue to work towards attainment of their rightful place, in science as in other fields, as partners with men, recognized for their individual talents and contributions without regard to their sex.

'AUSSIE' GASAT SONG

Chorus
Let's all hear it for GASAT
It's the place to be at
Let's all hear it for GASAT
It's the place to be at.

Verse 1
We all came from Down Under
Left the cold and the rain
Now we're here in Ann Arbor
With these people called Jane.

Chorus

Verse 2
We ate cakes for breakfast
No vegemite for our toast
Now we know what they're missing
We'll send some over by post.

Chorus

Verse 3
Start off each day at eight, mate,
Tumble out of your beds.
The "Janes" won't let us be late, mate;
No wonder we stand on our heads.

Chorus

Verse 4
We flew over with QANTAS
To share our fears with our peers
You don't have to be a smart arse
To have a science career.

Chorus

We all come from Down Under
To brighten the end of your day.
Doesn't it make you all chunder
To think we're flying away?

Chorus

(Words by Leoni Rennie, Lesley Parker &
Graeme Reynolds.)

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Gender and Science: Masculine, Feminine, or Neutral

The Squibb International Seminar

by

Jane Butler Kahle

The Squibb International Seminar focused on an issue which is both central and crucial to the entrance and achievement of women in science. That is, the effect of the masculine image of science due to society's sex-role stereotyping of science and scientists as male on both girls' choice of subjects to study and of careers to pursue.

Three international scholars were invited to address the gender issue in science and engineering. They were asked to direct their remarks toward the dilemma posed in a recent book, Reflections on Gender and Science, by Evelyn Fox Keller, who discussed the historical, psychological, and philosophical perspectives which had contributed to science's masculine image. Dr. Keller had expresed concern that her work had been inappropriately used to support the viewpoint that science must be feminized, both to increase the participation of women and to improve the practice of science. Leading scholars from the UK, Jan Harding, Australia, Lesley Parker, and the US, Lilli Hornig, were asked to address the issues of the masculinization of science and of an alternative, feminized science.

Their papers, which were supported by the Squibb Foundation, were presented at the final luncheon of GASAT 4. All incoming participants to the national meeting which followed the international forum were guests at the luncheon. The divergent views of the three eminent scholars which follow provided the intellectual highlight of the conference.

THE RECLAMATION OF SCIENCE : TOWARDS DIVERSITY

LESLEY H PARKER

SECONDARY EDUCATION AUTHORITY, NEDLANDS, WA

Introduction.

In this paper I begin by exploring one dimension of the genderisation of science. I then go on to discuss, with particular reference to school science, the possibilities this presents for the reclamation of science as an area of study with appeal and meaning for all students.

In defining the boundaries of the paper, I have been assisted greatly by my reading of Londa Schiebinger's Review Essay of the History and Philosophy of Women in Science, (1987). I have re-conceptualised Schiebinger's attempt to map the field of gender and science as a matrix of twelve cells. The rows of the matrix (labelled I-IV in the diagram) represent four conceptually different approaches to study in the field. The first could perhaps be called the "her-story" of science (as distinct from what O'Brien (1981) has termed "male-stream" history). Typified in recent times by the work of Margaret Rossiter (1982) it documents the previously obscured contribution of women to science. The second, underpinned by a vast literature, analyses the structural barriers to women's participation - institutional, educational and occupational barriers as noted in the work of Hornig (1984). The third focuses more specifically on alleged "scientific" definitions of the nature of men and women and on the "scientific" basis for essential differences between the sexes. The work of Hubbard and Lowe (1979) and Bleier (1984) has made an important contribution to this analysis. The fourth addresses the definition of science, seeking to explore, as Keller (1985) does, the conjunction between science and masculinity and the disjunction between science and femininity.

Cutting across these approaches are the columns of the matrix (labelled A, B and C in the diagram), representing three fundamental points of view. Again, following Schiebinger (1987:307) the first maintains that, because of their physical, psychological and intellectual make-up women cannot do science as well as men. Action to increase the participation and achievement of women in science would be seen as pointless by advocates of this view. The second view, however, holds that there are barriers (social, cultural, educational, occupational) impeding the participation of women in science and focusses on action to overcome these barriers. The third view, by contrast, makes certain demands on science itself - demands associated with the perceived need to "feminise" science.

	A No action warranted	B Action-integration	C Action-change science
I "Her-story"			
II Structural barriers			
III Definition of women's nature			
IV Definition of science			

My focus is on the cell at the intersection of IV-C. I will argue, particularly in relation to school science, that if science were promulgated not as feminist science, or masculinist science but simply as "good science" then there should be no place for cell IV-C in a matrix of the kind shown here.

Defining Science.

I deal first of all with the definition of science. How is science defined? Evidence for the masculinist definition is compelling. Keller (1985) in an elaborate historical, psychoanalytical and philosophical analysis systematically traces the roots of androcentrism in science back to the very origins of Western knowledge. She presents, in her historical analysis, three periods as critical in the evolution of contemporary scientific thought and practice - Platonic thought, Baconian science and the "new" scientific thought prevailing around the time of the founding of the Royal Society. She argues that the model of gender relations and the culturally bound definition of valuable knowledge during each of these periods ensured the exclusion of females from the evolving definition of science.

In her psychoanalytical analysis Keller employs object-relations theory to argue the association between objectivity and masculinity. Objectivity then becomes the link between science and masculinity, and the consequent self-selection of scientists as people who gain emotional satisfaction from their belief that they are "objective", neutral, able to "stand back" as it were, from their subjects.

Keller explores the relationships among objectivity, power and domination. She challenges the familiar, relatively static, unilateral definitions of autonomy and objectivity, and puts forward a model of both these concepts which is dynamic and interactive, taking account of rather than neglecting one's connectedness to others. The implications of her model for science are far-reaching. What emerges is a picture of science not premised on the desire to dominate, to master and to exercise power over nature, but on interaction with and internalisation of the "object" of inquiry. Keller notes, too, that such a picture, while not entirely legitimated in the rhetoric of science is not totally foreign to the practice of science.

Dualisms.

One consequence of the kind of analysis described above is that it can lead to a set of dichotomies or dualisms. "Different", "feminised" science emerges as a science premised

on order rather than law

on respect rather than domination

on a continuum of difference rather than a dichotomy

on involvement rather than detachment

on understanding rather than predicting

on empowerment from understanding rather than power to manipulate

on allowing the material to lead you to answer rather than imposing an answer to it.

As we all know, sets of dualisms such as these are ubiquitous in Western philosophical traditions. As Schiebinger points out (1987:331):

> The basic categories of modern thought have taken shape as a series of dualities: reason has been opposed to feeling, fact to value, culture to nature, science to belief, the public to the private. One set of qualities - reason, fact, object - came to represent constituents of rational discourse and scientific knowledge. The other set of qualities - feeling, value, subject - have been defined as unpredictable and irrational. When the dualism of masculinity and femininity was mapped onto these categories, masculinity became synonymous with reason and objectivity - qualities associated with participation in public spheres of government, commerce, science, and scholarship. Femininity became synonymous with feeling and subjectivity - qualities associated with the private sphere of hearth and home.

And here-in lies a double danger. First, the mapping of identifiable categories of human beings on to any set of dichotomies such as these denies the variation within those categories, denies the holistic nature of humanity and carries with it all the risks known to be associated with stereotyping. Second such dualisms represent one kind of tool for describing the world. However they are not used as such. They are posed not as hypotheses to be investigated, or as ends of a continuum, but as self-evident truths with predictive and definitional significance. As Bleier has noted (1984:197) "we tend to mistake our cognitive techniques to comprehend the universe for the universe itself".

If "science" and "not-science" are defined strictly in terms of these dualisms and if the set of dualisms includes "masculinity" and "femininity" then inevitably we force young people to risk an identity crisis in their choice of future study or occupation. For example, in Keller's words (1985:174) "any scientist who is not a man walks a path bounded on one side by inauthenticity and on the other by subversion".

I maintain that these dualisms have served their purpose - they have helped feminist scholars expose some of the problems inherent in a narrowly defined science and importantly they have helped us also to arrive at a definition of "good" science. Harking again to the work of Keller, it is important to recognise that despite the many contrasts she sets up, she nevertheless recognises the trap in substituting "feminine" science for "masculine" science or, as she puts it (1985:178) "one form of parochiality for another". As a scientist it is, understandably, untenable for her to advocate or even to support the total rejection and replacement of what she has identified as the currently dominant scientific paradigm. Rather, her vision is based on the transcendence of the bias she has identified in science, and on the reclamation of science as a human instead of a masculine activity. Pluralism and eclecticism are indeed fundamental to her vision of a scientific paradigm which "allows for the productive survival of diverse conceptions of mind and nature, and of correspondingly diverse strategies" (1985:178).

The critical point of my argument is that science abounds with manifestations of this paradigm. Keller herself acknowledges this - she

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refers on several occasions to the multiplicity of styles and approaches that constitute the practice of science (1985:125) although she clearly sees these as having a relatively minor impact on what she calls the "dominant rhetoric". In my view we should aim for all science to be "good" in the sense of allowing for a variety of modes of thought and practice. Both masculine and feminine science as defined in much of the feminist critique of science are "bad" science since neither is totally human.

School Science.

I turn now to school science and to what happens when knowledge is selected from a discipline for transmission in schools. Inevitably school knowledge represents something of a distillation of the essence of a discipline - perhaps in some cases an oversimplification. And this is precisely what has happened in the case of school science. In attempting to characterise "science" as an area of study, school curricula have emphasised in a very simple way, the things which are alleged to make science different from other areas of human activity rather than what science might have in common with other human activity. The "objectivity", "reasoned argument", and "real facts" of science are presented in opposition to subjectivity, irrationality and values of "not-science".

Let me give you just a few examples. Typically a child's earliest formal encounters with science are through being taught to conduct an experiment. This exercise usually emphasises scientific detachment, objectivity, perhaps even a theory or a law which the data are expected to fit, and usually do fit, given children who feel a compulsion to obtain the right answer. Consider the emphasis in school science on control and manipulation of variables and the complex calculations which accompany these exercises. Consider also features of school science such as taxonomies, which frequently show "man" at the top of the

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evolutionary tree - the epitome of nature as it were.

Such hierarchical orderings and fixed approaches to scientific enquiry reinforce a simple, relatively easily comprehended, linear view of science. This is, I maintain, seen as easier to teach than a view depicting the relationship of the knowing subject to the studied object as complex, egalitarian and interactive. It endures therefore as the prevailing view of school science and it is particularly powerful because of the vulnerability and impressionability of its audience. It is partly responsible, in my view, for the virtual rejection of science by females as soon as they are given the opportunity to choose other paths, and for the attraction to science of males for whom such a "world" view presents no problem.

The problem is that this is not a "world" view - it is in fact only half the world. It is a gross distortion, a caricature, of science, and it is unrepresentative of science as practised. For as long as we allow this caricature to dominate school science we will present females in science with an identity crisis such as that referred to earlier in this paper. For as long as we allow it to endure we will be led into strategies such as single-sex-classroom-grouping or choice-based-on-previously-acquired-interests, which treat the symptoms rather than the cause of the problem.

What is needed is a school science which reflects the diversity of scientific practice not the male-ness of much scientific rhetoric. We need text books and materials which depict the whole-ness, the human-ness and the inclusive-ness of scientific activity. Young women do not need to become "honorary men" in order to do science well. Rather science needs to be portrayed as the totally human activity that it is in reality.

I am not suggesting here that we don't have a problem. School science, without substantial financial support, is notoriously slow to change to incorporate new knowledge and other ways of doing science. Feminist scholars have helped us to identify and articulate the problem, however, and we should now move ahead to ensure that "good" science is presented in schools. Many participants in this conference, through their involvement in the selection and transmission of scientific knowledge and in teacher education, are well-placed to initiate such a move - well-placed to reclaim science as a human instead of a masculine activity and to play their part in ensuring that we can, indeed, celebrate diversity.

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Gender and Science in 1987

Jan Harding

Equal Opportunities Consultant

Introduction

I have been asked to present what I see as the current position on "gender and science". Analyses and discussions of this issue have proliferated over the past few years and I wish, first, to comment briefly on interpretation. The way one presents the issue depends, of course, on the way one perceives it, but also on the purpose of the presentation and who the intended audience is. A theoretical analysis would read rather differently, for example, from a paper which sets out to raise an awareness of the issue among teachers and to outline feasible (for them) strategies for changing the status quo.

There exist many different base-lines for perception of the low involvement of women and girls in science and technology as a problem. They arise from many sources, such as the industrialist who experiences a shortage of skilled personnel, the science educator who recognizes a failure to educate, the equal opportunity professional whose responsibility it is to remedy disadvantage, the feminist who seeks to elevate the status of women and the values they represent, the observer of science who attempts to understand how science is, and the practitioner who experiences discrimination or who feels threatened by criticism of the practice of science, to mention only some.

The range of these base-lines indicates the complexity of the issue and the need to listen and learn from others. The GASAT conferences provide a forum for such communication. Most individuals will view it from more than one base-line. The perspective from which I write is that of a feminist science educator, turned equal opportunities consultant, who has a passion to understand how things are and a fearfulness for the directions in which an apparently heedless use of technology is driving us.

I will assume my audience also recognizes the issue as complex, but that our perspectives may differ. I am acutely aware that the latter may inhibit communication, especially in a short presentation. All I can do, in the brief space allotted, is to point to the sources from which I have gained most insight and to indicate how they inform my own practice as science educator, equal opportunities consultant and citizen.

The Scientist and the Natural World

Physics is no longer known as "Natural Philosophy" in the English language, but the relationship between the scientist and the natural world is a crucial determinant of the kind of science that emerges. Easlea (1981) argues that Western science is inexorably bound up with masculine sexuality which has a need to dominate, penetrate and subdue a Nature which is framed as female. He finds violent imagery much in evidence in the writings of early modern (male) scientists.

Although most women scientists may deny they differ from men in their professional work, when women scientists reflect upon their science a different imagery results which includes concepts of nurturance, identification, humility, love and joy (Keller, 1983a; Goodfield, 1981, and Walton, 1986).

Keller (1985), in a series of collected essays, elaborates on these relationships. Drawing upon Chodorow's (1978) premise that the male's essential experience of the world is one of separation from it, while that of the female is connectedness with it, she argues that the psychologically-determined needs for separation and control lead to a particular kind of objectivity (static objectivity), to closure and to the suppression of the irregular. Where there is a greater sense of relatedness a dynamic objectivity may operate.

> Dynamic objectivity is...a pursuit of knowledge that makes use of subjective experience...in the interests of a more effective objectivity...the scientist employs a form of attention to the natural world that is...a form of love. The capacity for such attention...requires a sense of self secure enough to tolerate both difference and continuity. (Keller, 1985, p. 117)

Such a position requires, she argues, that both of Schrodringer's fundamental tenets of science - the belief that nature is (i) objectifiable and (ii) knowable - need to be relinquished.

The Personality of the Scientist

Like John Head (1985), with whom I worked closely in the UK, Keller sees an interaction between personal needs and the dominant ideology of science (which, however, does not truly represent the diversity actually displayed in the practice of science) giving rise to a self-selection of scientists and a perpetuation of a science with these characteristics.

> The severance of subject from object, as well as the insistence on the premise that science is affect-free, may derive in part from a heavily affect-laden motive for separateness and may serve to buttress a sense of autonomy. If so, then the continuing adherence to the belief in the objectifiability of nature would be assisted by the emotional functions served by this belief.
>
> (Keller, 1985, p. 148)

The Process of Science Choice

Strongly influenced also by Chodorow, a research student and I turned to object relations theory as a useful model to account for observed gender differences and their interaction in science choice. (1) Briefly, this model assumes that individuals create "objects" as a result of countless experiences of the person or institution (such as "school" or "science") to which identifying labels are assigned. The individual relates to these according to his or her needs. These needs are themselves nurtured in the individual by the daily responses of the caretaking environment as the infant moves from a state of complete dependency towards one of mature adult interdependence (Harding, 1986; Harding and Sutoris, 1987).

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(1) It was only later that we discovered Keller's analysis based on object relations theory and are indebted to her further insight.

If school science is presented as abstracted, law-bound, unemotional and enabling control, and this is not modified by other experiences to which the young person has attached the label "science", then the created science object will possess these characteristics and will be chosen by those whose needs it meets. These are mostly male. The presentation of science in this way frequently depicts the natural world as an object to be studied, taken apart, controlled and manipulated. A high-tech urban environment will reinforce the creation of such an "object."

Professor David Suzuki, from the University of British Columbia, Canada, drew our attention, at a recent conference in Australia, to the distaste for, and alienation from, the natural world that is common to urban children - "if you see something crawling you scream or stamp on it."

If, on the other hand, the young person has been enabled to develop a "capacity for concern" (Harding and Sutoris, 1987) and a sense of relatedness to others and to the natural world, the formal presentation of school science referred to above will appear irrelevant.

Some young people in this category may be fortunate in their school science experiences leading them to create a science object which has social implications - a factor which Ormerod (1971) has consistently found correlates with girls' choice of science but not with that of boys - and which interprets for them the natural world of their experience. The needs of these young people will also be met by the choice of science and, provided the created science object is not damaged irreparably by future study, they may become scientists practicing outside the dominant ideology of science.

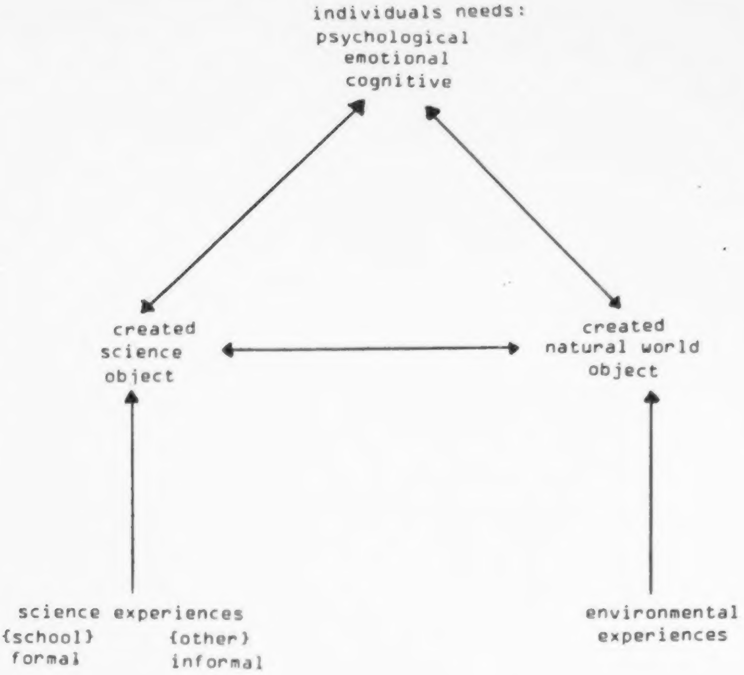
individuals needs:
psychological
emotional
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Figure 1. A model to represent the process of science choice.

> They will contribute to
>
> ...the diversity of values, methodological styles, and goals (that), to varying degrees, always exists in science....
>
> (Keller, 1985, p. 160)

Strategies for Change

From the discussion above you will understand that I am committed to the greater involvement of women and girls in science and technology. I recognize the employment opportunities available in these fields; I know that their study can afford an intense delight and satisfaction, but I do not see that the major obstacle lies with women and girls.

Most importantly we need to weaken the strength of what Keller calls "the dominant ideology of science". How should we proceed? The model discussed above suggests we should pay attention to the nurturing of young people, and particularly of boys, to avoid the generation of separation anxiety which leads to a need to dominate and control. Furthermore, we should present formal science within a framework of concern for persons, society and the environment, emphasizing connectedness, not separation, with a greater stress on the interpretive power of science. Its capacity for control and manipulation should be placed within a framework of concern.

As a science educator responsible for chemistry, I have been involved in the development of a modular chemistry course, for 14-16 year-olds, which starts from issues through which our use of materials hits headlines. By asking questions about use we reflect on purposes and on the properties and structures of materials (chemistry). Social responsibility is a major theme; the questioning nature of science and its interpretive power are emphasized (Harding and Donaldson, 1986).

The evidence from trials of these materials and other similar courses is that girls are much more readily involved. It is no longer "male science," but boys are no less enthusiastic in following it. How such a course affects their view of the world or of science has yet to be evaluated.

But we need, urgently, also to provide young people with experiences of the environment through which they are able to relate empathetically with the natural world. In the UK we have "school journeys" (but they are under threat from financial cuts and objectives sometimes get lost); in the U.S. you have summer camps (some of the young teachers I have trained have been involved in these) but we need to extend such experiences and integrate them into the study of science.

As an equal opportunities consultant I am asked to talk to science and technology teachers but also seize every opportunity to work with teachers in first schools, to address parent-teacher groups and to discuss with high school students their roles as future parents in the development of their sons and daughters. On each occasion I use the issue of women and science within my argument, but place it in the wider context of personal development and the future of our planet.

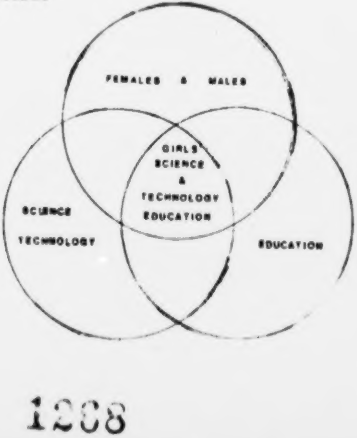
As a citizen I work through the Fawcett Society in the UK; my paper for GASAT 4 describes the strategies that the education section has employed over the last three years to challenge traditional attitudes and to support young women in non-traditional areas of study and employment.

In Conclusion

Although our insights have deepened and broadened since 1981, when the first International GASAT Conference was held in Eindhoven, I still find the model generated by those discussions a valuable one (Raat, Harding and Mottier, 1982), especially when introducing the issue to those who have not reflected upon it to any great depth. How it is with girls' science and technology education at any time or place will depend on the interaction of three broad factors:

- the expectation that society has of males and females,
- the philosophy, aims and organization of education, and
- the practice and presentation of science and technology.

If we wish to alter the existing situation we must effect changes in all three of these factors.



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GENDER and SCIENCE

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Among the many issues surrounding the topic of women in science and engineering, none is more durable nor recurs with greater certainty than the fitness of women for such fields or its converse, the fitness of science for women. These questions have been posed in all undertakings from which women were customarily barred, leaving behind a rich and entertaining tradition of speculation about and "reasons" for women's apparent deficiencies. The virtual absence of women from most highly respected activities was assumed to be the result of women's natural inferiority, grounded in a host of "scientific" reasons, ranging from small brain size to the famous raging hormones. In the sciences, the apparently small participation of women continues to generate theories based on biological or psychological sex differences even as the articulation of the theories magnifies the differences unrealistically. Among these is the thesis developed by Keller and others which we are discussing today and which has been so ably described by the preceding speakers.

Very briefly recapitulated, this argument is that the cognitive structure of modern science reflects, of necessity, the structure of male thought. Therefore it selects problems and approaches them with trains of reasoning that are attuned to competition with others and that seek control of nature, in place of an adaptive and cooperative mode postulated for women, largely based on psychoanalytic principles. Hence, women are assumed to be uncomfortable in the sciences, seeking out other fields more suited to their natures or even trying to redefine existing

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science fields in their own terms. The argument gains apparent support from the fact that women's participation in science and engineering follows a pattern similar to ours in many countries; it should be remembered, however, that these patterns also vary within very wide limits and that women's participation remains lower than men's in almost all professions requiring extended training, regardless of their intellectual content. Further, in this country and probably elsewhere, participation patterns also vary by race, ethnicity, and citizenship, by region, and by socioeconomic status.

In rough outline, the observed gender differences are usually greatest in the most quantitative fields -- engineering, physics, astronomy, some parts of computer science, and earth sciences -- although many of these differences have declined sharply since about 1970. The differences have essentially disappeared in behavioral sciences and have greatly diminished in the life sciences even as these disciplines have become increasingly rigorous, sophisticated, and quantitative. Mathematics itself presents something of a puzzle: contrary to widespread belief, it has been an almost sex-neutral field at the baccalaureate level for decades, but large sex differences continue to exist at the doctoral level.

One of the perils of women's studies is that almost by definition they focus on gender differences rather than similarities. We need to emphasize that in the matter of educational and career choices, women and men have very similar goals, hoping to maximize their chances for doing intellectually and emotionally satisfying work that will also be economically rewarding. As a host of societal and structural barriers to women's participation have diminished since the passage of our great civil rights laws of the 1960s, the educational and career patterns of men and women have in fact converged to a remarkable and quite unforeseen degree.

If academic field choices, and the career and life plans that derive from them, actually represented some fundamental, genetically determined differences between the sexes, they would have to be both more different between men and women and much more stable over time and place within each group. We have already mentioned how widely field choices can vary with region or country. They also change markedly over time; our most extreme case is engineering, where in 1970 a total of 358 women earned their bachelor's degrees compared to 11,195 in 1985. Again, in 1970 the total number of science and engineering doctorates earned by women was 1626, and in 1985 it was 5119. Surely no genetic change was occurring that could account for increases of this magnitude, nor was the basic nature of science adapting itself to a more subjective cognitive style. What changed during these fifteen years was the social context and the framework of opportunity, as expressed in laws providing for equal access to education and equal opportunity in jobs. These changes came about for several reasons, some of which were political, some idealistic, and some extremely pragmatic.

In the latter category, the money to be made by increasing the numbers of women students to rough equality with men was surely a compelling factor. Women were believed to prefer the study of languages and literature and thus were expected to utilize humanities faculties who might otherwise become surplus. The Carnegie Council on Policy Studies in Higher Education stated explicitly that formerly all-male colleges found women to be profitable because they "---[chose] fields of study that were not especially popular with men." (Carnegie Council, 1975). In the event, the new laws (especially the Women's Educational Equity Act) made it illegal to curtail women's participation in the sciences and in other professional curricula by such means as higher admissions standards or numerical quotas. With such constraints removed, women's educational choices became increasingly similar to men's.

Although in principle women have equal access to universities, in practice our most selective institutions are still allowed to maintain a 60:40 ratio of men to women. This means that some of the best women students can't necessarily go to the best universities. The most glaring inequalities of access, as we will hear during the next few days, come in financial aid, where men continue to get proportionately more public support while women continue to pay a larger share out of their own funds, at undergraduate as well as graduate levels. Among eleven science fields that confer doctorates, eight have financial support patterns that favor men by significant margins. (Syverson, 1982; Coyle, 1986; Russell Sage Task Force Report, Chapter 9, in press).

The ultimate effects of such inequalities have not been evaluated by empirical research, but their predictable results include greatly restricted options for women students. Less scholarship aid limits the choice of college, favoring a low cost, more or less local institution, which in many cases automatically limits course selections and graduate school options. Many of the colleges women can afford do not even offer a complete and competitive education in science fields, and have no engineering schools at all.

Women's educational choices, like men's, have always been closely linked to future careers. Women majored in education or nursing or home economics because those were the fields in which they could be sure of work. Now that additional opportunities are available, the number of women who graduate annually with a major in education, for example, is down by about 70,000, almost half of the total in just one decade. Conversely, the number graduating in business management each year is up by over 80,000, or more than eight-fold, during the same period. (Vetter and Babco, 1986). Between 1974 and 1984, almost 180,000 women moved out of humanities, education, and social sciences majors to take up more lucrative, newly accessible, and quite nontraditional fields. (Russell Sage, in press).

Trends like these do not argue for any fundamental differences between men and women either in cognitive structure or in those psychological traits that affect educational and career choices when the available options are similar. Rather, they suggest very strongly that we should seek explanations of these sex differences in continuing structural barriers to equality in both education and employment. Such a conclusion is also supported by comparisons between women's careers in science and in other fields that are commonly regarded as more feminine. For example, although it is true that the concentration of women in most science fields is below one-third, compared to about one-half in the humanities, the numbers of women scientists far exceed those of women humanists. Thus, among the total current stock of Ph.D.s in this country, there are about 63,000 women scientists and about 27,000 women humanists, or a ratio of 2.33. The ratio of new women Ph.D.s in sciences to those in humanities in 1985 stood at 3.44, so that the disparity is growing just as it has among men. The fields regarded as least congenial to women -- physical and mathematical sciences -- produced over 900 doctorates in 1985, contrasted with about 630 in the so-called traditional fields of English and other modern languages combined. (Maxfield and Brown, 1986; Coyle, 1986; National Academy of Sciences, 1987). Furthermore, the employment patterns of professional women show a remarkable consistency across a broad spectrum of fields from education, law and medicine to humanities and sciences, and in all employment settings. Although men's and women's careers can be compared along many dimensions, the single most informative measure of equity is the ratio of women's salaries to men's among those who are employed full time. In the sciences, that quantity currently is .85, and in the humanities it is just under .86, with very similar figures for other professions. Taking this comparison one step further to ultimate professional success, we find that more women have been Nobel laureates in the sciences than in either literature or peace endeavors.

Contrary to all the stereotypes, then, large numbers of women certainly do choose careers in science and engineering when the social context in which they must operate makes such careers possible. In terms of all the normal measures of career progress, women in nontraditional fields are at least as successful as those in traditional ones. Given that nontraditional fields and occupations also yield higher financial rewards, they should be the preferred choice of professional women. And in fact all the evidence is that they are.

The inescapable conclusion, I believe, is that those scholars who find women unsuited to science or science to women have based their thinking on an invalid premise. There really is no basis for believing that quantitative and analytical reasoning is an alien cognitive process for women. When we compare women to men, determining the relative proportions of each sex in various activities, we see great inequalities. When we compare women in one field to those in another, determining how they distribute themselves among the choices open to them, we discover two things: the patterns of choice resemble those of men, and the disadvantages women face are essentially invariant across fields. In short, women face some discrimination in all careers because they are women, not because they are unsuited to science or science to them.

The recognition that sex discrimination has not yet been eliminated is painful, but at least it leaves us some options in enlarging women's prospects. To put women on an equal competitive footing in all careers, we need a comprehensive federal family policy that safeguards the future of our children. To encourage young girls and women to enter nontraditional fields, we should stop intimidating them with the thought that they must be especially brave to become scientists and engineers because they will be lonely pioneers in an alien environment. They have no choice about having to live in a world where not understanding technology and science would be a far greater disadvantage than any discomfort they may suffer in their studies. As teachers and mentors, we have two obligations: first, to make clear that being female is not an excuse from life as it will be lived in the future; and second, to create academic and work environments where all their talents can flourish.

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The following opinion, representing a group of GASAT participants, was presented by Ina Wagner prior to the final, open session.

The Recruitment of Women into Science and Engineering: Is There a Moral Dilemma?

by

Ina Wagner, Austria

For some participants the idea of GASAT includes a commitment to changing science and technology as well as the belief that women ought to take an active part in the change process. However, when it comes to defining the direction of necessary changes and the values involved, the diversity of political cultures and personal responses to political issues among women becomes visible. Opinions on whether it is desirable and legitimate to challenge the predominant values within today's science vary among women. Moreover, it cannot be taken for granted that women agree about the direction in which science and technology should develop.

In spite of these difficulties some participants attempted to identify common tasks and themes. One of the tasks is to examine the social contexts within which women scientists and engineers, with their numbers increasing, could set activities in the direction of desirable change in their field. There are differences between types of work-organizations and political structures as to how much compliance they demand from those participating in them. In order to be able to initiate change there has to be some space for control over the products of one's own work as well as over decision-making processes. It was felt by some that in particular the research that is linked to the military minimizes the degree of control to a level where change is virtually impossible. Those participants felt that a large part of science and technology research today is directly or indirectly linked to military uses. This makes it the more important to carry out careful analyses of work environments into which women scientists and engineers might possibly be integrated and evaluate what chances they might have to contribute to changing science and technology.

The results of these analyses need to be integrated into educational programs, in particular in those aiming at young women scientists and engineers. In the opinion of some, those young women need to understand how work organizations and political structures function and how those aspects affect the course of scientific-technical development. The argument was put forward that although selection of one's workplace is essentially a question of individual choice, there is a need for a collective responsibility for science and technology based on shared norms and standards. In the opinion of some, experience has shown that demands for a more socially responsible behaviour of those who contribute to the development of science and technology cannot be fulfilled on the level of individual responsibliity only. GASAT might contribute to creating a basis for a collective responsibility.

This idea contains a series of questions that need to be debated more fully:

- Do we need such a core of shared values in order to promote the aims of GASAT?
- Can we agree on the premises of changing science and technology while at the same time paying respect to the diversity of political backgrounds and beliefs?
- How can we proceed from knowing how science and technology should not develop to an image of a desirable future science and technology?

It was suggested by representative participants to consider the themes of the decade for women - equality, development, peace - also a centerpieces of a better science and technology. It was felt, however, that these ideas need to be carefully thought out and debated. This debate could be an important part of the next GASAT conference.

A

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American Association for the Advancement of Science

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Corning Glass Works

ERIM Corporation

Ford Motor Company Fund

Honeywell Incorporated

Lilly Endowment, Incorporated

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National Science Foundation

The Procter and Gamble Company

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Michal Kollan (Israel)
Judy Bazler (US)
Eve Humrich (US)
Mary Trowbridge (Kenya)
Charlotte Iiams (US)
Anne Davies (Australia)
Eleanor Linn (US)
Pauline Vegting (Netherlands)
Ilja Mottier (Netherlands)
Lore Hoffmann (Germany)
Gaell Hildebrand (Australia)
Margaret Bearlin (Australia)
Sandy Farkas (Canada)
Sharon Haggerty (Canada)
Asenath Sigot (Kenya)
Leah Marangu (Kenya)
Richard Simpson (England)
Barbara Reilly (New Zealand)
Gunn Imsen (Norway)
Jan Raat (Netherlands)
Sue Lewis (Australia)
Cecily Selby (US)
Kerrie Mullins Gunst (Austr.)
Nancy Kreinberg (US)

Curriculum Theory and Development (Integrating Science-Society-Technology)

Ruth Carter (England)
Ilja Mottier (Netherlands)
Pauline Vegting (Netherlands)
Nancy Kreinberg (US)
Sue Lewis (Australia)
Walter Smith (US)
Kerrie Mullins-Gunst (Australia)

Early Childhood Education

Charlotte Iiams (US)
Richard Simpson (England)
Anne Davies (Australia)

Computer Equity

Ina Wagner (Austria)
Tamar Levin (Israel)
Barbara Reilly (New Zealand)
Jo Sanders (US)
Jan Stockdale (England)
Ruth Carter (England)

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Feminist Science

Sharon Frantz-Lutzer (Canada)
Ruth Carter (England)
Anne Walton (England)
Jan Stockdale (England)
Ilja Mottier (Netherlands)
Else-Marie Staberg (Sweden)
Margaret Bearlin (Australia)

Nina Kopola (Finland)
Vivi-Ann Langvik (Finland)
Ellen van Oost (Netherlands)
Anne Davies (Australia)
Sue Lewis (Australia)
Sylvia Benckert (Sweden)
Alejandra Leon Castella (C.R.)

Research Methodology

Michal Kollan (Israel)
Gail Jones (US)
Tamar Levin (Israel)
Jan Stockdale (England)
Amanda Katili (Indonesia)
Paulina Pages (Philippines)
Sheila Pfafflin (US)

Hadassa Horn (Israel)
Nadine Hinton (US)
Mary Trowbridge (Kenya)
Jan Raat (Netherlands)
Lore Hoffmann (Germany)
Elizabeth Hegarety-Hazel (Aust.

Psychological Aspects of Gender

Michal Kollan (Israel)
Sandy Farkas (Canada)
Mary Trowbridge (Kenya)
Kristina Edlind (Sweden)
Ilja Mottier (Netherlands)
Sheila Pfafflin (US)

Tamar Levin (Israel)
Jan Stockdale (England)
Anne Walton (England)
Gunn Imsen (Norway)
Pauline Vegting (Netherlands)
Alejandra Leon Castella (C.R.)

Gender Differences

Gail Jones (US)
Eve Humrich (US)
Anne Walton (England)
Pauline Vegting (Netherlands)
Sheila Pfafflin (US)

Nadine Hinton (US)
Barbara Simpson (US)
Gunn Imsen (Norway)
Alejandra Leon Castello (C.R.)